A REPORT ON THE DEVELOPMENT OF A MULTIMEDIA INSTRUCTIONAL UNIT ENTITLED MICROCOMPUTERS: HOW THEY WORK

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by

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A Thesis submitted in partial fulfillment
of the requirements for the degree
of Master of Education

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May 1986

St. John's Newfoundland

ISBN 0-315-31028-6

Abstract

While the use of microcomputers continues to escalate in all sectors of society, their application for teaching and learning purposes in provincial and national schools remains with the committed few. Present and past literature suggests educator unfamiliarity with microcomputer technology is still largely responsible for this condition, though other factors such as poor courseware, few authoring languages, and costs are prohibitors as well.

To assist with the task of familiarizing a large local population of educators with the microcomputer and its capabilities, a multimedia instructional package, entitled Microcomputers: How They Work, was designed and developed by the writer.

During the course of development the learning materials were edited, revised, and examined in preparation for a formal, thorough evaluation of their effectiveness. A statistical analysis suggests the package was responsible for 30 elementary school teachers demonstrating learning of both concepts and skills as well as affective improvements with respect to microcomputers.

Microcomputers: How They Work, is now available for use by government, school boards, and other agencies responsible for teacher education and professional development who wish to instruct local educators in the broad areas of microcomputer form, function, and instructional utility.

Acknowledgements

The design and production of instructional materials is frequently a time consuming and arduous task requiring, among others, assistance from people with a variety of backgrounds, knowledge, and skills. Therefore, in this space, the author would like to thank the following persons for their support throughout the life of this project. Firstly, deep thanks to Dr. R.T. Braffet, my supervisor, who provided eternal assistance and always an open door. To Wallace Boone, photographer and friend, whose favors were too numerous for mention. Finally, to my wife Susan: Your encouragement, understanding, and technical assistance were essential for the completion of this package.

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CHAPTER I

INTRODUCTION

In a short time period of perhaps forty years, the forward march of computer science, microelectronics, and related technologies has deeply penetrated most areas of human endeavor creating widespread social, economic, and intellectual change. Few areas of society now remain untouched as these achievements have invaded business, government, science, education, and more recently, the home.

At the centre of this metagenesis is the computer, an instrument which unlike any other development, such as the printing press or the assembly line, has extended man's greatest asset - his mind. As a result, society is in a transition, moving from the clutches of the industrial revolution to the arms of the information age.

More precisely, it is the present day state-of-the-art microcomputer with its miniscule silicon chip which has made low cost, powerful, and reliable computing available to the public at large. A recent prediction by Pressman and Rosenbloom (1984) suggests even deeper permeation of this technology as 60 million North Americans are expected to purchase microcomputers by the end of the decade. Indeed, if present purchasing trends continue coupled with the hoards of microcomputer hardware, software, courseware, course offerings, demonstration fairs, publications, computer clubs, and interest groups available throughout Canada, the United States, Japan, and European nations, this prediction should materialize.

Just as the microcomputer is creating upheaval in society, the industry it represents is undergoing swift change as well. Since 1975, when the first microcomputer, the Altaire 8800, was introduced, these machines have continually decreased in cost and size, yet similarly, are more powerful and portable. One of the few features that has remained constant is, perhaps, its purpose; that is, to receive, store, manipulate, and communicate information (Toong & Gupta, 1982).

History of the Computer

Present day computer technology is the result of a lengthy evolution exceeding 3000 years. The first widespread computational device, the abacus, was used to perform simple calculations such as addition and subtraction and with greater difficulty, multiplication and division. Today, this process of counting via string and beads is still widespread in the Orient.

Tedious tasks such as census tabulation and taxation were catalysts for development of the earliest mechanical calculators. Beginning with Pascal and his "ratchet gear" calculator in 1642, the process of calculation and the science of mathematics was significantly advanced by Leibniz and the Leibniz wheel (1694), Jacquard's weaving loom punch cards (1804), and Babbage's difference machine and analytical engine (Baker, 1975). But it was Hollerith in 1879 who developed the first truly successful computation device. With the use of punch cards and several Hollerith calculators, the United States census of 1890 was completed within three years - a task which previously took many times longer.

Though Hollerith's calculator was eventually replaced by a more complex system, the digital punch card (a thin paper card containing information in the form of punch holes) continued to be used as a standard data source. With the advances of technology in the 1920's and 1930's and the demand created by an oncoming war, International Business Machines (IBM) and Harvard University engineers collaborated to produce a swifter, more capable unit, the Mark I. A huge apparatus (51 feet long, 8 feet high, 5 tons), this electromechanical mechanism could perform all four mathematical functions within seconds and store data in memory banks - something its predecessors were unable to do.

In 1946, there emerged a calculating machine which revolutionized computation technology. Termed ENIAC (Electrical Numerical Integrator and Calculator), this was the first automatic electronic digital computer. Housed in a framework 30 by 50 feet were 18,000 vacuum tubes which could compute in milliseconds and perform functions not found in earlier computers. However, ENIAC, EDVAC (Electronic Discreet Variable Automatic Computer) and other "first generation" mainframes were large, unreliable, (with its vacuum tubes having to be replaced every 7 or 8 minutes), costly to produce, operate, and difficult to program. As well, data were processed in a "batch" fashion; that is, users were not "on line" (directly communicating) with the host computer, but were required to have their programs or data delivered to the computer installation for processing, much as one delivers photographic film to a developing facility. Such a mode had particular disadvantages as Sledge (1979) points out:

> Programs could be sent by post, by courier, or delivered personally by teachers or friends but the essential feature of such an arrangement was usually that it was self-defeating because of the delays involved. After all, the speed of the computer can hardly be demonstrated by an arrangement that takes days, if not weeks, to produce the results. (p. 6)

The appearance of the transistor in 1947 was a significant departure from vacuum tubes. This tiny amplification device (no larger than a dime) was smaller, more reliable, and highly efficient compared with its predecessor and soon was used by industry for production of the "second computer generation". These mainframe computers, as they were termed, featured a reduction in cost and size over ENIAC, and were inherently more powerful - reflecting the advantages of microelectronics.

Paralleling these hardware developments were improvements in computer utilization, particularly the advent of "time-sharing". In the time shared mode, multiple users pseudo-simultaneously access a central computer facility through on line communications. Each user appears to be serviced immediately, though in fact, the computer shares service time with all clients in a rotating fashion.

Technological progress in the early 1960's was responsible for the advent of the integrated circuit - an electrical pathway consisting of many interrelated transistor elements etched on a small piece of silicon. These "chips", as they are called, were a significant development, eliminating the need for individual transistors within electronic components. As a result, the "minicomputer" or the "third generation" of computers arose. Minicomputers were robust, desk size units characterized by rapid program execution and a large memory capacity, storing anywhere from 32 - 128 K (thousand) words. Its cost was substantially less than earlier models as expensive assembly practices (such as hand wiring) were eliminated. Furthermore, this new hardware provided increased time-sharing facilities (upwards of 100 or more clients) resulting in lower user per terminal expenses.

Throughout the following decade, microelectronic improvements continued to reduce computer costs and increase efficiency and processing capabilities. Small scale integrated circuitry of the early 1960's (accommodating about ten transistor elements per chip) was, by 1970, upgraded to medium scale circuit integration and soon followed by large scale circuit integration (thousands of transistor elements per chip) in the mid-1970s. With these developments, the electronic means was now available for developing a 4th generation of computers.

In 1975, the first microcomputer appeared on the market (Braun, 1977). Built for the hobbyist, the Altaire 8800 could be purchased in kit form for a cost of $339.00. It was the first low cost, desk top, stand alone computing facility available to the public at large. The "new computer era", as Barnes (1979) labels it, had arrived.

The current microcomputer is the focus of a flourishing market and reflects the swiftness with which the technology changes. Four, eight, sixteen and thirty-two kilobyte random access memory with monochrome display units and magnetic tape cassettes were in vogue five years age. State of the art "micros" marketed for business, educational, government, and leisure use presently boast 64 K or 128 K random access memory via very large scale integrated circuitry, compact keyboards, high resolution monochrome and color display units with touch sensitive screens, high speed printers, disk drive units, voice and music synthesis, and multimedia hook-up capability. Compared to ENIAC and its 1 K random access memory, a several hundred dollar state-of-the-art microcomputer and its silicon square is 1/30,000 the cost, 1/30,000 the size, capable of executing programs 200 times faster, extremely energy efficient, and inherently more reliable - an impressive cost/effectiveness ratio (Boraiko, 1982).

Future developments in microcircuitry and information storage augur well for further cost and size reductions, as well as increases in capability, applications, and "user friendliness". For example, Hewlett-Packard has now produced a chip accommodating 450,000 transistor elements (Brahan, 1983) and researchers at North Carolina State University expect to utilize molecular memory for data storage in the near future (Shane, 1983). This latter development may make the chip obsolete before its full potential is realized.

Clearly, technological progress in the micro-electronics and computer industries will further encourage the permeation of computing into most sectors of society. Such a development will require, among other things, present and future workers to be knowledgeable with respect to computers and their applications (Bozeman, 1984). Indeed, present day preparatory training for engineers, business personnel, secretaries, and teachers openly reflect this trend.

Educators, in particular, are being handed the responsibility to educate the learning public in computer literacy and utilize the microcomputer for instructional purposes (Green, 1984). Amid cries of accountability and progressive education, such tasks must be accepted willingly and with understanding.

Present Computer Applications in Education

As stated previously, computers and particularly microcomputers and associated paraphernalia are being marketed and purchased on a scale unheard of in history. The field of education is no exception to this trend as "micros" are permeating schools, central offices, and colleges to assist with instruction, instructional management, and administrative tasks (Pressman & Rosenbloom, 1984).

The terminology to describe these applications is widespread, but varied, and appears to have evolved as the industry found greater applicability for the technology. Presently, the literature is flooded with terminology and acronyms to describe similar computer applications (Moore & Collins, 1979). Some include computer aided instruction (CAI), computer administered instruction (CAI), computer assisted instruction (CAI), computer aided teaching (CAT), computer managed learning (CML), computer based learning (CBL), computer based instruction (CBI), and computer managed instruction (CMI). In his 1971 paper, Salisbury identified 21 terms dealing with computers in education. Today, there are perhaps many more.

Presently, computers (microcomputers, minicomputers, and mainframe computers) are used for instructional and administrative purposes (Hirschbuhl, 1981). Instructionally, they assume important roles in drill and practice, tutorial, simulation, dialogue, problem solving, testing purposes, teaching computer science and literacy, and for instructional management. Administrative uses include record and data keeping, and accounting.

Further division of the computer's instructional utility into direct instructional activities and instructional management has become commonplace. These have been widely termed CAL and CAI for the instructional roles, while CML and CMI are acronyms for instructional management. As Hunka (1977) states, CAL and CAI are essentially synonymous, as are CML and CMI. Beyond these broad titles, particularly what constitutes CAI (CAL) and CMI (CML), disagreement and variation prevail. Zinn (1978), for example, follows the (1977) American National Association of Users of Computer Aids to Learning (NAUCAL) classifying scheme and includes learning about, with, and through the computer under the CAL heading, while computer managed learning is viewed as "learning support systems" encompassing computer managed instruction, guidance, and materials generation. Rushby (1979) defines CAL as "teaching with the aid of a computer" but does not consider learning "about" computers (e.g., computer science studies) as an element of this area.

Smythe and Lovatt (1979) use Hooper's (1978) terminology and define CAL as using the computer as a "learning resource" and CML as the "management of learning", yet fail to explain clearly just what these terms mean. Rushby (1979) further suggests that overlap between CAL and CML systems occurs since both contain instructional and instructional management functions.

At least two authors view educational computing as being divided into learning with, about, and through the computer (Zinn, 1978; Braun, 1984). For the purposes of this paper, it is convenient to categorize the broad term computer based education (CBE), or educational computing, into the distinct areas of instruction and administration, based on how the computer is applied in educational settings. The instructional strategy (CAI or CAL) may be further divided into learning through the computer, which include drill and practice, tutorial, dialogue, simulation, and testing; with computers, or learner controlled computing whereby the student solves logic problems via computer programming; and about computers, which include computer literacy courses, computer science and data processing courses. This hierarchy is similar to that suggested by Braun (1984) and the NAUCAL, as reported by Zinn (1978).

An Historical Overview of Computer Based Education

The current wave of enthusiasm in computer based education may be traced to the late 1950's (Suppes & Macken, 1978). Developments in transistors coupled with research in programmed learning and teaching machines inspired educators to seek new methods with respect to delivering instruction.

By 1957, computers were being used on a much greater scale for government and business purposes and soon colleges began utilizing them to aid in research and administrative duties, as well as subjects of study. The computer industry used them to train their own personnel (Suppes & Macken, 1978). Educators literate in this new technology saw computers as a means of achieving one of education's fundamental goals - individualized instruction (Scanlon & Connolly, 1974). Research in the instructional applications of computers had begun at the University of Illinois and by 1959 a computerized instruction system to be used for widespread instructional purposes was installed. It was called PLATO, an acronym for Programmed Logic and Teaching Operations (Baker, 1975).

At this time one of the major aims of industry was to improve hardware from an economic standpoint and develop languages which could be used by teachers and other educators (Watson, 1972). Research by IBM in the late 1950's led to the development of an authoring language, Courseware I; however, its low level (machine oriented) nature made it far removed from the programming skills of the average teacher. It was nevertheless an important step toward the production of an effective time sharing system (Blaisdell, 1976). Other work in author languages was done by the Sperry-Univac Company. Their goal was to design a CAI system incorporating a high level language which could be used by educators to develop courseware. I B M and researchers from Stanford University were also exploring the potential of the system 1500, a new development which would contain innovative hardware such as light pens, advanced cathode ray tubes (essentially T.V. monitors) and an audio feature.

Considering however, the emphasis placed on computerized instruction, its widespread use by educators was being hindered by several factors (Braun, 1977; Scanlon & Connolly, 1974).

1. Cost. Few educational institutions could afford the price of a computer plus peripheral hardware such as teletype machines. Furthermore, staffing was expensive due to scarce well-trained personnel (Hirschbuhl, 1980).
2. Illiteracy. The vast majority of educators were computer illiterate and knew little, if anything, about the potential of the computer for instructional purposes.

3. Processing Technology. "Batch time" was the common form of computer processing and its inherent disadvantage of delayed feedback made it inefficient (Braun, 1977).
4. Courseware Development. For the educator, producing courseware (CAL lessons in the form of a computer program) was not only time consuming but difficult as well, since high level (English oriented) author languages were nonexistent. Therefore, most computer based lessons were of inferior quality since they were designed by computer programmers who often lacked educational backgrounds (Blaisdell, 1976).

Despite growing criticism that the computer would dehumanize society, research in computer based education (CBE) continued to expand in the 1960's with the help of the American National Science Foundation (NSF) and educational institutions such as Dartmouth College, Massachusetts Institute of Technology (MIT), Pennsylvania State University, The University of Texas, and the National Technical Institute (Von Feldt, 1979).

In the mid-1960's, a number of developments occurred which profoundly influenced the future of CBE. The appearance of cheaper, more efficient minicomputers, capable of "time sharing", reduced costs substantially by permitting a number of users to access the computer simultaneously. No longer was it necessary to wait extended periods of time for required feedback (batch time processing) as persons were now "on line", - that is they had direct communication with the central processor (computer) via teletype or typewriter.

Publication of the Pierce report in 1965 was the necessary impetus needed to increase CBE research. This paper recommended greater emphasis by the United States government in the instructional uses of computers for education. In response, the United States National Science Foundation supported the funding of a number of CAI projects including:

1. PLATO. (Programmed Logic and Teaching Operations). Today, PLATO is perhaps the largest CAI network in operation. Its extensive courseware (instructional software) is marketed by the Control Data Corporation for Canadian and American educational institutions. Furthermore, much courseware has been adapted for use with Apple and other micro-computer systems (Crone, 1982). This step should further encourage its proliferation throughout educational environments.

2. TICCIT. (Time Shared Interactive Computer Controlled Information Television). This system was developed as a joint operation between the Mitre Corporation and the American National

Science Foundation and presently combines computer and television technologies for instructional delivery (Barker, 1979).

3. <u>Project LOGO</u>. Under the direction of Seymour Papert and the LOGO group at Massachusetts Institute of Technology (MIT), a family of languages has been developed for use by young children. Project LOGO has received considerable attention recently, particularly with respect to advanced theories of cognitive development (McNeill, 1984).

4. <u>The Huntington Computer Project</u>. In the late 1960's and early 1970's, Braun and Visich, in association with the National Science Foundation, explored the computer's use as a teaching resource for the pure sciences, social sciences, and languages arts. Braun (1979) claims the Huntington Computer Project was useful in designing a model for courseware development and identifying the value of simulations in education.

Educational computing in Britain has also been characterized by large scale research and development projects. These include:

1. <u>The Chelsea Science Simulation Project (CSSP)</u>.

   Its purpose was to design and produce discovery based science experimental simulation materials. Project development began in 1971 and ceased in 1976; however, materials are still marketed by the Edward Arnold Corporation.

2. The National Development Programme in Computer Assisted Learning (NDPCAL).

   Perhaps the most influential of British computer assisted learning projects, the NDPCAL developed well conceived learning materials in most subject areas (Smythe and Lovatt, 1979). Having commenced in 1973, the NDPCAL was terminated in 1981.

3. Computers in the Curriculum Project (CCP).

   Under the direction of R. Lewis the CCP investigated the computer's application in teaching science and mathematics. The CCP lasted for a duration of 7 years, 1973 - 1980. Materials produced are presently distributed by the Edward Arnold Corporation.

In the mid-1970's, development of the microcomputer with its silicon chip microcircuitry established, perhaps beyond any single development of the Post World War II years, the potential for widespread, deeply seated, and inexpensive computer facilities in educational settings. In fact, as Brahan (1983) acknowledges, the future of CAI - when the computer augments teaching and learning - may lie not in large instructional networks like TICCIT and PLATO, but in stand alone, relatively inexpensive and portable microcomputers which are now marketed by venders such as International Business Machines, Tandy Electronics (Radio

Shack), the Commodore Company, and Apple Limited. Supporting the available hardware is also a large supply of instructional, administrative, and leisure software from commercial sources, though authorities are less than favorable about its quality and instructional appropriateness. Some recent literature by Dean (1982) and Bork (1983) clearly reflect this belief.

Instructional Usage

I. Computer Assisted Instruction

Instructionally, the microcomputer may be used to learn about, with, and through computers. These three broad applications subdivide into specific areas of study as outlined by Zinn (1978).

1. Learning about the computer

(i) Computer literacy. In North America, computer literacy is the fastest growing area of computer learning (Johnston, 1985). It is the study of computers, their function, and effects on society.

(ii) Data processing. The computer is used to perform operations on data and achieve a desired output.

(iii) Computer science. The study of computer system maintenance operation and technology, as well as computer literacy, awareness, and programming.

(iv) Personal computing. The family use of micro-computer technology for purposes ranging from electronic games to tax preparation.

(v) Inservice training/Professional development. In this role, the microcomputer is a vehicle for skill development and training. Recently, computer inservice and extra service programs for teachers and administrators have gained popularity to keep educators abreast of technological and instructional changes.

2. Learning through the computer

Historically, the main thrust of research and development in CBE has been in this area (Braun, 1984; Zinn, 1978). In its traditional role, the computer is a vehicle for instruction in several ways.

(i) Drill and practice. In this mode, the computer assists the learner acquire mastery of previously learned material; however, no new stimuli or lessons are presented. Hunka (1977) has described three drill and practice models or sub-strategies. These include a random model whereby exercises are presented in a fortuitous manner; a fixed model which presents the learner with a limited set of problems; and a mixed strategy which incorporates characteristics of the others. Whatever format is used, the computer assists the teacher by drilling the learner in previously instructed material. Many drill and practice programs are available particularly in the areas of language arts and mathematics. Notable vendors include the Control Data Corporation which markets PLATO educational materials for large networks, as well as the Bell and Howell Company.

(ii) Tutorial. This strategy is instructionally broader than drill and practice as tutorials provide instruction in new material, test comprehension through questions, formulate feedback, and recommend supplementary exercises, if needed. Like drill and practice, the computer controls the activity while the teacher serves as an external source should system or comprehension problems ensue. Many tutorial programs are based on an option or "branching" strategy whereby material for presentation depends on learner characteristics and behavior. As Watson (1972) suggests, such a method has great potential to fully individualize instruction.

Tutorial programs exist on a large scale throughout North America and the United Kingdom in most subject areas. Hunka (1977) lists several which have been developed in the field of medicine at the University of Alberta. These include <u>Cardiology</u>, which introduces the learner to heart murmurs, <u>French</u>, designed for the beginning French student at the grade ten level, and <u>CAI programming</u>, which tutors in the IBM COURSEWRITER authoring language. In Britain, the NDPCAL program has produced celebrated tutorials in mathematics, while the Computers in the Undergraduate Science Curriculum Project (CUSU), under the direction of J. McKenzie at the University College London, has made available materials in most science curricula. PLATO and TICCIT, American CAL systems, have also generated tutorial programs, some of which are now marketed by microcomputer software houses. For example, Altos Computer Systems and Intelligent Systems Corporation retail accounting and word processing and computer training programs respectively.

(iii) Dialogue. Through dialogue, the student and microcomputer communicate in an unstructured, sophisticated manner through the use of natural language. Instruction, testing, and feedback are all elements of CAL dialogue, but, unlike tutorial and drill and practice programs, the computer is programmed to accommodate a broad range of student responses such as extraneous use of language, answers in a variety of orders, and incorrect spelling and syntax. A major drawback of dialogue is the onerous programming required to produce an effective unit. One large and complex dialogue program is <u>SOPHIE</u> developed by Brown, Burton and

Bell. SOPHIE attempts to teach students how to "troubleshoot" faulty electrical equipment by answering questions, supplying necessary data, and communicating informatively with the learner.

Pressman and Rosenbloom (1984) state relatively few microcomputer based dialogue programs exist, likely due to programming complexities. A more recent innovation is oral dialogue between learner and computer but costs still remain prohibitively high for serious instructional applications.

(iv) Testing. Microcomputers may also assist with testing and evaluation. For instance, diagnostic testing is helpful to identify student knowledge and skills prior to instruction, hence, assisting the instructor in goal formation and lesson preparation. Formative testing is useful during drill and practice, tutorial, or dialogue modes to assess comprehension and understanding. A microcomputer item bank contains a pre-determined number of questions which may be displayed prior to, during, or after instruction. A more sophisticated method involves the computer generating items randomly, thus avoiding repetition. Computer based testing has particular advantages over traditional pen and paper methods. For example, test items and their order of presentation are hidden and evaluation and feedback are immediate. A major disadvantage is the difficulty in accommodating "free" (or open) response items - a word sentence, for example, since the author must anticipate potential answers. Hence, for microcomputers multiple choice, matching, and true/false items are suggested.

3. Learning with the computer

In this mode, the computer or microcomputer is used for educational gaming, word processing, problem solving, as a simulator, a data base, and an aid to assist in heuristics (or discovery learning). Several authors claim the greatest reward from computers, cognitive development, lies in this application as the computer is controlled by the learner and not the learner controlled by the computer (Papert, 1980).

(i) Educational gaming. Educational gaming is a recent application of the computer. The computer and the learner engage in a competition with learning and/or skill development as ultimate goals. Braun (1984) claims the learning potential through "gaming" is largely untapped and "once their potential is realized, they will provide rich learning experiences for students" (p. 113). A typical application of gaming may be found at the University of Pittsburg. Engaged in a star-wars type conflict, learners must apply laws of trigonometry on projectile flight and angle setting to destroy the enemy.

(ii) Simulations. Simulations model real world events, laws, or other phenomena which would otherwise be impractical to encounter in reality. They may exist as "stand alone" projects or be incorporated in other CAI strategies such as tutorials or dialogue. Simulations (or electronic models) are attractive to educators for several reasons. Firstly, as modelling agents, they mimic world events which may be too dangerous, costly, or difficult to encounter. Typical examples include operating a nuclear power plant or piloting an aircraft. Secondly, as a dynamic (active) system, the learner must interact with the program - an activity which encourages the development of higher order intellectual skills (Walker, 1983).

Lipson and Lipson (1980) state that simulations may be created for most, if not all, real world phenomena and cite population growth, political negotiation, and chemical reactions as examples. In the past, well received simulations have been developed by members of the larger educational computer projects. Some examples include Inheritance by the British Computers in the Curriculum Project and pH by members of the U.S. based Huntington Computer Project. A commercial current simulation for microcomputers is

Projectile Motion Workshop by High Technology Software Products Inc. The program illustrates projectile motion under the influence of gravity with the provision for learner interaction through manipulation of various parameters.

(iii) Problem solving/Data storage/Calculator. In this mode, the computer's computation and storage capabilities are utilized to reduce time and effort on otherwise onerous tasks. Used as a calculator, vast amounts of data may be manipulated in microseconds using complex formulas. In the problem solving mode, the user develops programs for the computer or uses those marketed commercially.

(iv) Creative activities. The computer is now a medium for creative expression through art, music, design, poetry, and programming. In fact, it may be the creative aspects of microcomputing that addict long term users called "hackers". Such users spend endless days and nights exploring the computer's capabilities and potential applications. The LOGO languages provide children with the programming means to explore the computer's potential and actively create as they wish.

Of course, while the uses of the microcomputer for teaching purposes are many and varied, roles are not necessarily independent. That is, tutorial programs may include some dialogue and simulation. Similarly, electronic models may exist alone for example, simulating population changes over time. As technology advances, particularly with respect to authoring languages, most software may be a "soup" of instructional strategies.

II. Computer Managed Instruction (CMI)

The computer may also be used to assist with instructional management. A distinction between this strategy and CAI is that computer managed instruction (CMI) is used to coordinate learning opportunities, while in CAI, the computer is directly involved in the teaching process.

Specifically, CMI may serve the teacher by addressing the following tasks: Record and student data keeping; Instructional goal formation; Guidance and selection of learning events and materials; Assessing and evaluating learner performance; Instrument construction - tests/attitudes/surveys.

A simplified CMI program may proceed in the following manner. Students are assigned learning activities which reflect instructional goals. They progress through the recommended activities and, depending upon their performance (which has been evaluated by the computer), be promoted to the next lesson or assigned remedial work. In this way, the computer has tested, corrected, and assigned activities for the learner, thus assisting the teacher with time consuming administrative tasks.

Traditionally, instructional management appears to have lagged behind CAI, but as Allen (1980) notes, CMI is expanding gradually with a significant percentage of schools using computers for this purpose. In the past, several successful CMI large scale systems emerged in the United States and Britain for use in public schools. Some of these include the Automated Instructional Management System (AIMS); Program for Learning in Accordance with Needs (PLAN); Wisconsin System of Instructional Management (WIS-SIM); Individually Prescribed Instruction/Management System (IPI/MIS) and Instructional Management System (IMS); Computerized Instructional Support System (CISS); PLATO Computer Management and Instruction (PCMI); Air Forces Human Research Laboratory (AFHRL); Hertfordshire Computer Managed Project and Computer Assisted Management of Learning (CAMOL) (Splittgerber, 1979; Smythe & Lovatt, 1979). CMI programs are commercially available for microcomputers. The Grade Storage Diskette, for instance, is marketed by Coronet Instructional Media for use with most microcomputers.

Non-Instructional Usage

I. Administrative Applications

Computers, and particularly microcomputers, are being applied on a greater scale to assist with school administrative tasks (Johnston, 1985). The technology is being applied to assist in the scheduling of courses, recording of student data and records, materials inventory, accounting, and budgeting. With the vast amounts of information contained on data sheets in any school office, the utilization of a powerful microcomputer for information storage and handling is time saving, convenient, and efficient. Marshall (1982) claims that over 80 percent of school management functions can now be handled by micro-computers.

Programs for these purposes may now be purchased from software houses for use on most common microcomputer systems. For example, IBM's Socrates program performs administrative routines by properly arranging and scheduling students' courses, classrooms, pupils, and teachers.

Barone (1985) states that a successful application of a large scale computerized administrative system has occurred in the Metropolitan Toronto Separate School system. Since its adoption, the computerized information data base has provided improved student placement, decision making, and planning services with increased reliance and cost savings.

Past and Present Canadian Trends in Computer Based Education

Traditionally, computing in Canadian colleges and schools was a subject of study rather than a vehicle for the delivery or management of instruction (Knapper & Wills, 1984). Meeting the need for more research in its instructional potential became the responsibility of research organizations and institutions of higher education such as the National Research Council (NRC) and the Ontario Institute for studies in Education (OISE).

In 1969, the NRC and the OISE in association with Canadian educational institutions and business firms embarked on a research and development project in CAI (CAL). Its aim was to "ensure the availability by 1980 of a viable and cost effective computer aided learning system for Canadian users" (Brahan, 1976, p. 1). Through a life of twelve years, the project involved on-line connection to a host of colleges and universities including the OISE, McMaster University, the University of New Brunswick, the University of Calgary, Algonquin College, and Carlton University. Its purpose was to improve CAI technology in network communications, hardware and software, authoring languages, and learning materials production techniques. Brahan (1976) notes the project was successful, particularly with respect to the development of the National Authoring Language, acronymously known as NATAL. NATAL is an advanced high level programming language for educators who wish to design and produce learning materials. The Course Management and Preparation System (COMPS) is another NRC based activity. It is a sophisticated courseware preparation system, programmed in NATAL and requiring no specialized skills on the part of the instructional developer (Wilk, 1983).

Throughout the country, additional research in CAI has occurred at the University of Waterloo with the development of a multi-media instructional system termed COMIT (Computerized Multi-Media Instructional Television). Knapper (1980) states that during the project's life, a range of learning materials were produced including simulation and drill and practice programs. In Manitoba, Sandals, McMillan and Workman have initiated a project to develop CAI materials in mathematics, languages, and life skills for urban and rural schools in Manitoba (Sandals, McMillan & Workman, 1980). At the University of Alberta, Bent (1980) notes that the Division of Educational Research Services, under the direction of Steve Hunka, has, since 1967, been active in developing CAI materials. Other computer based projects, both past and present, include the installment of PLATO hardware and courseware at the University of Quebec (Blanchet, 1980); testing and the teaching of statistical data analysis via computer at the University of Guelph (Hallett, Law, & Holt, 1983); and CAI applications for the handicapped at the University of Calgary (Brebner, Clarke, & Johnson, 1983). Undoubtedly, other research has occurred elsewhere.

A large scale Canadian telecommunications network with great teaching and learning potential is the TELIDON system. TELIDON is a two way interactive television system under the auspices of the Canadian Department of Communications and incorporates television monitors, computer terminals, telecommunications links, and intelligent courseware. Muter, Treurniet, and Phillips (1980) claim that TELIDON will become increasingly sophisticated and may eventually permit Canada wide teleconferencing with computing facilities for educators using NATAL and a national information network.

Indeed, CAI trends in Canada have closely mirrored those of the United States and elsewhere. Essentially, short lived computer based education projects confined mainly to institutions of higher education and government departments were created to explore and harness the potential of the computer as an educational aid. The NRC of Canada, a major thrust of CAI research, has been credited for pioneering exploration in authoring languages (NATAL) and production techniques in CAI materials' development.

Despite, however, some intensive though sporadic research in this field, CBE, particularly the computer's use as a tool for instruction, is not being applied to a large degree in either Canadian colleges or schools. Such a condition appears to contradict marketing trends as micros are being purchased by these institutions at a rapid rate (Rich, 1983). A closer examination, however, reveals growing application as a subject of learning and administrative tool relative to its instructional utility which appears confined to the "committed few" (Rich, 1983).

Computer literacy, in particular, has gained considerable popularity in recent years among public and education decision makers. This trend, while heralded by many to be the therapy for an unhealthy education system, is not without its critics. Opponents claim computer literacy alone is poor utilization of a potentially fruitful resource; that predictions for future widespread programming skills by young people are overstated; and computer literacy is merely educators' response to the public's clamor for a more progressive, practical education (Menosky, 1984; Bernstein, 1983). Reasons aside, much initiative is focused on computer awareness, making it the fastest growing area of CAI in Canada (Rich, 1983).

A review of literature pertaining to the Canadian status quo of microcomputer use shows clearly that Canadian provincial departments of education are making efforts to ensure that computing is nested in the curriculum, albeit the intensity of implementation and programs offered varies provincially and even locally. Recent efforts in support computer based education may be found throughout the country. British Columbia, for example, has purchased ten thousand

Apple microcomputers to be distributed to B.C. schools. While controversy regarding model selection has surrounded this purchase, it nevertheless demonstrates the government's intention to implement microcomputers in B.C. education. Through the Computer Technology Project, the Alberta government is planting computer literacy programs and microcomputing in provincial schools. The Bell and Howell Edumod System was chosen as hardware with significant price reductions offered to schools. Similar initiatives are occurring in Manitoba where computer awareness courses are being developed for primary, elementary, and secondary schools. Ontario and Quebec have taken firm steps to promote educational computing. Ontario guidelines for introductory computer studies published in November, 1983 outline goals and objectives for the newly introduced high school literacy program. Further, that government has allocated funds for the development and review of courseware and invested heavily in the development of a Canadian education microcomputer which would assist in hardware standardization throughout the country (Rich, 1983). The Quebec government has recently announced its intent to purchase forty-two thousand micros over a five year period. This is a significant venture considering Quebec's problems identifying useful french language courseware and keyboards. In Saskatchewan, a computer literacy outline serves as a basis for the locally developed literacy syllabus. Kemp

(1983) acknowledges that computer literacy is well established throughout the province's school districts but, like most provinces, is unevenly distributed. Further east, the Prince Edward Island Ministerial Advisory Committee was established in 1982 and specified goals in computer literacy and awareness for implementation in junior and senior high schools. New Brunswick and Nova Scotia have taken similar initiatives. All three maritime provinces have embarked in a cooperative effort to catalogue and index educational computer software (Rich, 1983). Presently, New Brunswick, Nova Scotia, and Prince Edward Island provide a computerized career guidance data base to eastern region high schools.

Locally, the Newfoundland Department of Education has made efforts to promote computer based education in Newfoundland high schools. In 1981, the Computer Studies Curriculum Committee established goals and objectives for a new high school computer literacy course, Computer Science 2206. This course is now available as an option in many Newfoundland schools and introduces the student to the history, operation, and capabilities of the computer, programming skills in BASIC, available careers in computer technology, and the role and impact of computers in society. To assist schools with implementing the course, a monetary grant to purchase hardware and software is available.

This account is indicative of recent efforts by Canadian governments to wedge computer based education in provincial curricula. Undoubtedly, more is now happening at the district and school levels. For example, some schools are raising funds for the purchase of microcomputer equipment independent of government support. Teachers, as well, may be offering aspects of computer studies as additional components of mathematics or social studies curricula. Parents are purchasing microcomputers for family use with firm beliefs children will be prepared for the information age.

Nevertheless, while microcomputers are becoming more widespread, they presently are not deeply seated in Canadian schools. Where pervasion does occur, however, the focus of learning and teaching is computer literacy, and to a lesser degree, computer science and programming followed by its application as a tool for instruction and instructional management (Rich, 1983; Knapper & Wills, 1984). It is generally agreed these last two applications hold great promise for education with respect to individualizing instruction and creating new learning experiences, yet ironically, they have made little impact on the Canadian classroom. The literature addressing this problem is extensive and the reasons varied, but similar to those which plagued CAI in its formative years. According to Anastasio and Morgan (1972), CAI's problems have been economic, technical, and educational. The high cost of hardware, coupled with poor instructional materials and a computer illiterate teaching populace were great obstacles for pro-computer educators. Hawkins (1978), through a survey of computer-educated college teachers from the United States, Canada, Britain, and the Netherlands, isolated anti-computer based instruction factors common to all these countries. Included were computer illiteracy, a fear of its technology, and its high cost. Other authorities such as Bunderson (1971) claim that besides cost, the non-identification of the target populations' needs and college educators' resistance to computerized instruction impeded its proliferation during this time. Baker (1976) has attributed CAI's problems to few training environments and poor cost/performance ratio. Molnar (1971) suggests that in the past, few incentives have been provided for educators to produce software. The unwillingness of administrators to pay in accordance with productivity and difficulties in receiving credit for production of materials have contributed to the plight of computerized instruction. Recent literature by Manion (1985), and Marshall (1982) argue that appropriate software scarcity is a great impediment, but Dean (1982) claims further that poor authoring languages are equally impeding.

Much current literature also focuses heavily on the importance of teacher training and knowledge with regard to computers and their applications. Concerns echo the belief that computers are firmly established in society and that computing will be a necessary skill for the future, yet a substantial teacher population is without knowledge and training to teach about computers or apply them effectively in the classroom. This clearly can be seen in literature of Manion (1985); Johnston (1985); Giannelli (1985); Green (1984); Bozeman (1984); Pressman and Rosenbloom (1984); Smith and Sage (1983); Clouse and Savage (1982); and Bork (1983). As Bruwelheide (1982) notes, the literature is often repetitive and the authors see the common need for teachers to become computer literate and at the very least, computer aware. As mentioned previously, Hawkins (1978) found among Canadian college educators literate in computer technology that, besides cost, lack of knowledge and self-confidence were chief barriers to the spread of CAI in this country. While such a report is now eight years old and many teachers have upgraded in the area, recent evidence indicates that a substantial teacher population is still without the necessary knowledge and skills to further the computer's use in teaching and learning.

A 1983 United States National Education Association report, A Teacher Survey NEA Report: Computers in the Classroom probed U.S. teacher attitudes and competencies in computer technology. The results parallel concerns reflected in the literature - that a substantial teacher populace is without adequate training and knowledge in computers and their educational applications. Specifically, the survey revealed that while teachers see the importance of educational computing skills, particularly to assist with instruction, less than four percent felt they were well informed in computer programming, selection criteria, commercial courseware and software, computer components, operation characteristics and computer types. Moreover, almost 60 percent of teachers surveyed were interested in computer programming, computer operation, and instructional applications - three criteria considered to be fundamental for appropriate computer use in the classroom. With regard to the global issue of teachers' needs and concerns in the area of instructional computing, "the greatest needs among teachers are for computer knowledge and experience" (p. 56). Among those teachers who already use computers, the need is for well designed, effective software. Finally, over 60 percent of the respondents were interested in taking an instructionally related computer course, demonstrating a majority interest in upgrading. These findings are supported by other less recent research. Stevens (1980) in a comprehensive survey revealed similar impressions regarding American teacher knowledge in computers. For example, an overwhelming majority (90%) of respondents felt unqualified to teach even computer literacy. Again, while the NEA report is three years old and teachers' nationally are upgrading in the area, it is unlikely that computer literacy is deeply rooted in a vast majority of Canada's 50,000 educators.

The literature suggests that impediments to widespread CAI applications are not unlike those fifteen years ago. However, in light of technological advances in hardware, authoring languages (NATAL), significant cost reductions, and an increasing availability of inexpensive, albeit questionable design software, these problems appear to be less significant than past years (Pressman and Rosenbloom, 1984). Educator illiteracy in computers and their applications, however, still reigns as a deeply rooted widespread problem affecting all nations (Bork, 1983). Some exceptions to this may be teachers in Minnesota, Manitoba, and British Columbia where courses have been available for some time.

As a response to this crisis, as it has frequently been called, there are global initiatives in the form of pre-service, in-service, and extra-service programs of study. Some, such as ITMAL in Plymouth, England and REACT in Oregon, U.S.A., have been offered since the early 1970's. Luba (1975) acknowledges that a teacher education program in computing has existed in Manitoba since 1975. However, these programs were mostly local attempts and research based.

Current initiatives in the U.S. and Canada include pre-service credit courses for teacher trainees, as well as in-service and extra-service credit and/non-credit courses for those presently teaching. Some states and provinces are considering legislation requiring teachers to take a recognized CBE program prior to licensing.

Green (1984) notes that 14 American states have enacted legislation requiring some formal study in CBE. Most Canadian colleges and universities now offer courses in CBE and school boards, in cooperation with these institutions, are promoting computing in their districts. Rich (1983) claims these have been successful and teachers are eagerly taking advantage of such learning opportunities. Bork (1983) is rather less positive and states that education faculties offer, for the most part, inadequate teaching in CBE - often just one or two courses, and effective in-service courses are uncommon. Nevertheless, these efforts are indicative of attempts being made to educate a large computer illiterate teaching populace with the broad goal of encouraging widespread CBE, particularly the computer's role in learning and instruction.

CHAPTER II

NEEDS ASSESSMENT

Introduction

From the previous account of educational computing in its formative years to the present status of CBE in Canada, it is likely the computer, particularly the micro-computer, will continue to grow as a compelling and pervasive influence in government, business, and education (Shane, 1983). Canada appears to be no exception to these trends as we can expect continued utilization of computer facilities in all sectors of society. Newfoundland schools, like those in the rest of the nation, should show a noticeable increase in microcomputer applications for administration, instruction, and learning. Concern, however, has been expressed that a large body of local educators, unfamiliar with the computer's use and capability, could conceivably hamper the healthy utilization of microcomputer facilities and, where facilities do exist, not apply them to their fullest potential.

Broad Goal

Given this apparent spread of microcomputer hardware and software throughout provincial schools and district offices to augment the curriculum (Computer Science 2600;

other literacy courses which may be delivered at the elementary and junior high levels) and as a vehicle for learning (instruction, instructional management, problem solving uses), it stands to reason that those responsible for teaching and applying this resource should possess appropriate knowledge and skills for its effective utilization. Lunetta (1975) has identified four primary reasons for teacher familiarity with computer based education.

- To facilitate student development of skills and knowledge in this technology which will prepare them for future computer related occupations.
- To participate in the design and production of computer based learning materials which will supplement the curriculum.
- To modify their teaching styles for appropriate and effective use of computer based learning materials.
- To aid in decision making with respect to the use and purchase of computer based learning facilities.

Skills in the development of computer based learning materials can be justified from instructional and economic viewpoints. The computer's effectiveness as a teaching and learning resource has been studied extensively (Pressman & Rosenbloom, 1984). Compared with traditional forms of instruction, CAI has been shown to increase learning, retention, motivation, and interest in learners (Walker, 1983; Ashbrook, 1984). Cost savings for the school by not purchasing commercial software can be extensive and the product developed to meet a local need, should have high applicability and effectiveness. Time constraints, however, make serious computer based education materials production by school teachers unrealistic, as few educators have available the man hours needed to design and develop software. This author feels, however, that developmental skills are valuable as they can augment the educator's overall ability to assess the value of other commercial materials and production techniques.

CBE training should also prepare teachers for a role that will vary considerably from traditional pedagogy. The application of microcomputers for instructional purposes will alter the role of the teacher from one who disseminates knowledge to one who disseminates access to knowledge. Its broad instructional utility can absorb and relieve the teacher of many instructional and corrective functions. Mundane tasks such as record keeping and data keeping will be lessened. In these respects the teacher will invariably have more time to act as student guide and proctor.

There may also emerge a demand for special competencies in computer based education. Specialists in cybernetics, learning theory, instruction, and instructional management strategies, hard/software, and so forth may become reality in the not too distant future.

Status Quo (Existing Condition)

In light of the social, economic, and educational similarities between Newfoundland and the other Canadian provinces, there is no reason to believe our primary, secondary, and college teachers are significantly more informed with respect to computers and their educational utility than educators elsewhere in the nation. While reliable data is unavailable at this time, preliminary information gathered by Dr. Lionel Mendoza of the Faculty of Education, Memorial University, suggests that a substantial majority of Newfoundland educators are without the skills and knowledge to effectively support computer based teaching and learning. Possible exclusions to this generalization would include teachers with backgrounds in computer science, experience related to computer operation, or those who have completed recognized studies in CBE.

The Need

Given this discrepancy between a teacher population which should be skilled and knowledgeable with respect to computers and their applications and a teacher population which likely is without these skills or knowledge, there exists an inherent need to increase teacher knowledge in computer form, function, and its utility in educational management, teaching, and learning. Furthermore, the need is instructional, as these teachers are missing a necessary body of information and skills that may be gained through some instructional means.

Alternative Solutions to Meet the Need

Meeting the need to familiarize a significant population of Newfoundland educators in microcomputers and computer based education will require a determined co-operative effort on behalf of government officials, school board personnel, school administrators, and teachers. Effective course offerings, inservice, and extraservice staff training, appropriate learning materials, computer software and hardware are required to ensure our teachers utilize effectively a learning resource with proven teaching and learning potential.

Presently, the Faculty of Education, Memorial University, offers present and potential teachers course work in computer fundamentals and applications. Through the Division of Learning Resources, for example, graduate students explore the computer's utility in education and develop effective computer based learning materials. At the undergraduate level, students are introduced to microcomputer form and function as part of the general introductory media course.

Inservice programs have also been offered by school boards throughout the province. However, these are confined mainly to teachers of computer studies and not the teaching public.

Some time ago, the writer in conversation with a member of the Learning Resources Division was told that few meaningful instructional materials are available to supplement course offerings and inservice programs offered by school boards and the Department of Education. If this was the case, then perhaps an opportunity exists for production of a potentially valuable instructional development project.

In conversation with some other educators - teachers, Department of Education personnel, and school board officials - similar concerns were expressed, relating to both the content and media form of available materials. Specifically, some aids are outdated (Electronic Computer Operations, a 16 mm motion picture film, distributed by the National Film Board of Canada) while many of the more recent productions (the Fast Forward series, for example) provide little opportunity for personal interaction, though several examine in detail computer system operation, societal implications/applications, and educational utility. Other concerns reflected a desire for an informal simple treatment of computer operation basics with an introduction to its educational applications and, if possible, supported by a "hands on" component. Technical interests focused on inexpensive media which provide easy access to content, pacing of instruction to suit audiences with varying interests and capabilities, and ease of operation, duplication, and distribution of media.

A potential need for computer based learning materials to augment course and inservice offerings being provided is itself not justification for developing new materials. After all, fitting or partially fitting materials may already exist to meet the said need. Should a search for suitable computer based instructional aids prove fruitless and modifying existing packages is not feasible, then resolving the discrepancy remains with adopting newly developed materials.

Survey of Available Materials

In the search for computer based learning aids, several important criteria were used for evaluation purposes. These included materials which meet the specified behavioral objectives (see p. 64), and media which provide for large group instruction, pacing, ease of use, inexpensive upgrading, duplication, distribution, and a provision for learner interaction with a microcomputer system.

The instructional developer visited the following facilities, institutions, and offices in search of appropriate learning aids related to computers: The libraries of Memorial University and the city of St. John's; The National Film Board of Canada, Pleasantville; The Instructional Materials Division and the Division of Instruction, Department of Education; the Centre for Audio Visual Education (CAVE) and Resource Clearinghouse, Memorial University. All materials, whether print, film, or videotape were examined on the basis of the criteria cited previously.

Print Materials

The result of this search disclosed an overwhelming amount of print material. Journals, texts, newspaper articles, and miscellaneous publications dealing with all aspects of computer technology are available to the educator. Indeed, the amount of print material generated daily is indicative of the speed with which the field is growing and changing.

The instructional developer found, however, that the available print resources - either alone or in combination with other media - do not meet the major requirements for a desirable and effective instructional package. Broadly, print materials (particularly texts) are expensive, they cannot be practically upgraded and revised by the holder, and provide no direct opportunity for "hands on" experience. Many, however, do provide detailed information and are instructionally well crafted. Due to the immense amount of print resources a complete listing for this report is not feasible. Included, though, is a condensed directory to a variety of textbooks, journals, and other publications dealing broadly with computer form, function, and educational utility.

Textbooks

From Dits to Bits, A personal history of the electronic computer. Herman Lukoff. Robotics Press, 1979.

The author gives a detailed history of computer development - from ENIAC (Electronic Numerical Integrator and Computer) of World War II years to the products of large scale integrated circuit developments of the 1970's. This is a relevant history text but is not useful as an introductory form and function manual. A helpful computer user's glossary is provided.

Using the Computer in Education. A briefing for school decision makers. Paul Watson. Educational Technology Publications, 1972.

Watson's text is a thorough assessment of the computer's potential for teaching and learning. The author devotes considerable attention to describing the elements of a typical CAI system, the advantages and disadvantages of CAI, some present applications, and research findings in CAI. Though not technically overpowering, Watson assumes the reader has some basic knowledge in computer architecture and function. Hence, while a useful resource text for persons studying CAI, Using the Computer in Education is not recommended for the microcomputer novice requiring basic technical information on computers.

An Introduction to Educational Computing. Nick Rushby. Redwood Burn, 1979.

This is one of several texts written by Rushby on the topic of computers in education. Unfortunately, it assumes the reader has a fundamental knowledge of computer design and thus will not furnish him with answers to basic technical questions. Like Watson's publication, however, it is a useful resource text for information on computer based education and would augment closely a learning package such as Microcomputers: How They Work.

The Computer in the School. Justine Baker. Phi Delta Kappan Foundation, 1975.

Likely, a landmark text in computer based education, Baker discusses computer history, applications, societal and educational issues and future expectations. Again, like those texts discussed previously, it fails to discuss computer make-up and function. The language level is very suitable for the novice and hence is recommended as a supplementary text.

The Apple Connection. An Introduction to the Techniques and Principles of Apple Computer Interfacing. James F. Coffron. SYBEX INC., 1982.

Many instructional texts on microcomputer operation and make-up focus on particular models. Users find such texts useful for providing additional technical information seldom included in the owner's manual. This text concentrates on Apple microcomputer languages, architecture, and terminology. It is highly technical for a newcomer to the field and for most microcomputer users, deals with impractical processes such as analog to digital conversion. The text is too specialized for the microcomputer beginner.

Home Computers: A Beginner's Glossary and Guide. Merl K. Miller and Charles J. Sippl. Dilithium Press, 1978.

Home Computers is typical of those first texts on microcomputers. It provides an interesting historical overview, school and societal applications, the binary number system, and microcomputer architecture. Its language level is elevated for the micro beginner but it may be useful for the advanced student.

Computers in Early and Primary Education. Douglas H. Clements. Prentice-Hall Inc., 1985.

In this recent text, Clements intends to teach educators the many applications of computers, how these may be used with elementary school children, priorities in selection of software, and a host of other topics. This is a valuable text and would be an excellent resource for educators seeking more detailed information in educational computing.

Computer Based Instruction. A State of the Art Assessment. Harold F. O'Neill. Academic Press, 1981.

The text is an aggregate of submissions by guest authors. Almost everything related to educational computing is addressed including computer managed instruction, courseware, hardware, learning strategies, evaluation, and so forth. Several recognized authorities including Victor Bunderson and Karl Zinn contribute, however, given the level of technical language, Computer Based Instruction is more suited to the experienced computer student.

Computers Today. Donald H. Sanders. McGraw-Hill Inc., 1983.

Computers Today is a beginning text for introductory computer science courses. All topics - from a discussion on the need for computer literacy to programming skills to computer form and function are addressed. Generally, it is a well designed, non-technical text with pleasing graphics and photographs. Though Sanders fails to address extensively the computers' utility in education, Computers Today provides for the beginner a comprehensive overview of the technology. There are, of course, numerous introductory texts of equal merit and any would augment well Microcomputers, How They Work.

Computers - Sizes, Shapes and Flavors. J.M. Johnston. Dell/Banbury Publications, 1983.

Johnston's book is designed for elementary school children (grades 4 to 6). However, it would serve the adult novice as well. All topics, beginning with a history of counting and numerical calculation are dealt with simply, effectively, and without intimidating technical jargon. This is a useful text and is quite suitable for further reading in computer basics.

Bits, Bytes, and Buzzwords: Understanding Small Computers. Mark Garetz. Dilithium Press, 1983.

This is a recent softcover manual, suitable for the adult beginner. Garetz probes the contents of a basic computer system, available peripherals and their functions, purchasing tips, and a guide to software selection. Well designed at an appropriate language level, it is recommended for further reading by interested learners.

The Good Computing Book for Beginners. Dennis Jarrett. ECC Publications, 1983.

Most everything dealing with computers is dealt with here. Jarrett addresses all topics - from a discussion of input to purchasing hints - in a simple direct manner. It is softcover, inexpensive, and would augment well Microcomputers: How They Work.

Sharon's Beginner Computer Book. Sharon Publishing Incorporated, 1984.

Also a recent softcover manual, Sharon's Beginner Computer Book is similar in design and intent to the Good Computing Book for Beginners. Some humorous illustrations assist with maintaining its non-formal approach.

Dictionary of Computing. Oxford University Press, 1983.

This is a thorough collection of computer and electronic technical terms and language. It is suited for both the beginner and advanced computer scientist as a reference text, but is relatively expensive. Some of the publications described earlier would be more suitable for the novice.

Journals, Newspapers, and Other Publications

During the last decade, the huge demand for microcomputer literature to support purchasing trends was swiftly met with a rapid increase in the number of educational, technical, and business journals.

In the field of educational computing alone, many publications appeared to meet varying needs. Today, the following are some of the more influential journals and newspapers which provide technical advice, software/hardware trends and expectations, product reviews and educational, developments and research.

1. Computers and Education. Pergamon Press.
2. Computers and Society. Association for Computing Machinery (ACM)
3. Educational Technology. Educational Technology Publications.
4. Mathematics Teaching. Association of Teachers of Mathematics.
5. Learning. Springhouse Corporation.

6. MicroNotes on Children and Computers. ERIC Clearinghouse.

7. ComputerWorld Canada. Rattray Publications.

8. ComputerWorld. C.W. Communications Group.

9. PC World Canada. Rattray Publications.

10. Educational Software. Garlinghouse Company.

11. Computer Buyers Guide and Handbook. Computer Information Publishing Company.

12. InfoAge. Plesman Publications.

13. Personal Computing. Hayden Publications.

14. Popular Computing. McGraw-Hill Publications.

15. Creative Computing. Ziff-Davis Publication Company.

16. New In Computing Magazine and Buyers Guide. Computer Education Services of America.

17. UNIX/WORLD. Tech Valley Publications.

18. Computer Software. International Publishing Company.

19. PC Ziff-Davis Publishing Company.

20. Scientific American. Scientifican American Incorporated.

21. BYTE. BYTE Publications.

Filmstrips

Basic - An Introduction to Computer Programming. The Centre for Humanities, New York.

Four filmstrips introduce the learner to programming skills using the BASIC language. The set has many instructional merits but is more suited for course work in programming - not as an introduction to microcomputer form and function. There is very little emphasis on how the computer works or its applications, and hence, is recommended for the programming student.

16 mm Films

Electronic Computer Operations. The National Film Board of Canada, 1963.

This film provides an overview of computer input and output processing operations and discusses technical hardware. It is well designed and produced but is, unfortunately, outdated. Electronic Computer Operations would serve as an interesting resource from a historical perspective.

And Now The Chips Are Down. British Broadcasting Corporation, 1977.

If the intent of this film is to alarm and awaken the viewer, then And Now the Chips are Down has succeeded. It is a frightening assessment of the global impact of microelectronics on society. Subtopics include the production of silicon chips, work implications, life style changes, and future trends. This film does not address the functional aspects of computers and microcomputers nor their present educational uses. Nevertheless, And Now the Chips are Down is an excellent film to supplement any discussion on the social impact of computers.

A Computer Glossary. Encyclopedia Britannica Films, 1969.

A huge amount of technical information and computer jargon is compressed into this ten minute film. Boolean logic, subroutine, nmemonic, nanosecond are some of the terms addressed. Certainly, this is not an instructional aid that demonstrates simply and clearly how a computer works. For the computer novice, A Computer Glossary may intimidate more than explain.

Computers. Bailey Film Associates, 1970.

Computers provides an instructionally effective overview of computer form and function. It deals simply and clearly with the concepts of input, output, storage, the binary number system, and time sharing. Unfortunately, some content is technically outdated (the use of punch cards, for example; no microcomputers) and educational applications are not addressed. Historically, it may be of some value as well.

Videotape Materials

Bits and Bytes. TV Ontario Television Series, 1982.

To assist with its microcomputer academy, TV Ontario designed and produced twelve one-half hour programs on microcomputers, their operations, and applications. Each program is a detailed study of one particular area of the technology. Program one, called "Getting Started" addresses the concepts of bits, bytes, computer logic, hardware, and so forth. Of interest is "Computer Assisted Instruction", an overview of the microcomputer's use as a teaching aid.

Bits and Bytes is a thorough analysis of microcomputers and meets most, if not all, needs for a computer course. However, because the learner requires a video cassette recorder associated with the microcomputer, "hands on" experience is rather difficult to apply. Further, because of the videotape format and its associated drawbacks (cost, compatability, and so forth) Bits and Bytes is recommended as a support resource for more detailed study in particular areas of microcomputers and educational computing.

Fast Forward. TV Ontario, 1978.

Fast Forward is a series of twenty-six videotapes on computers and associated technologies. Each is a polished, professional analysis of the microelectronic revolution's impact on some sector of society. The videotape, "Education", provides an overview of the computer's use for teaching and learning. These are excellent resources and would complement any level of computer study.

Rationale for Development of the Materials

As a result of the search for suitable instructional materials related to microcomputer form, function, and educational applications, the instructional developer found no appropriate learning aids which satisfy the need for a complete, effective learning package to be used by provincial school boards and teacher training institutions for the purpose of training local educators.

Hence, given a condition of available but inappropriate learning resources — many of which having some applicability, but requiring major modifications (updating, transfer to more suitable media) — the decision was made to design and develop locally a learning package to meet the need still outstanding. In consultation with the instructional developer's supervisor, the package would be entitled, Microcomputers - How They Work.

Outline of the Developmental Process

This learning package, Microcomputers - How They Work, was conceived, designed, and developed through the systems approach to instructional design as described by Hannum and Briggs (1982). This process attempts to achieve educational results based on learner needs.

Broadly, the procedure is as follows: Learner needs are identified through a systematic analysis of instructional goals and existing conditions. Tasks, skills, and concepts to be learned are identified, priorized, and stated behaviorally according to learner characteristics. Following this, media are selected, and the package evaluated, revised, and upgraded until an effective, polished module remains. Finally, the materials are duplicated, packaged, and prepared for dissemination to the public in need.

In the chapters to follow, these stages will be dealt with in greater detail. A graphic illustration of the systems approach to instructional design follows on page 60.

Needs Assessment (Chapter II)

(i) Goals identified and compared with status quo.

(ii) If discrepancy exists then a need is identified.

(iii) Instructional goal stated.

↓

Instructional Design (Chapter III)

(i) Learner Analysis.

(ii) Tasks/skills/concepts stated behaviorally as learning outcomes (behavioral objectives).

(iii) Media chosen systematically.

↓

Developmental Procedures (Chapter IV)

(i) Design and Production.

↓

Evaluation (Chapter V)

(i) Package evaluated by learners and expert appraisers.

(ii) Results examined for learner gains and achievement of instructional goal.

(iii) Revision of package, if needed.

↓

Dissemination (Chapter VI)

(i) Duplication, packaging, and distribution to learning facility.

Figure 1. Instructional Design Procedures.

CHAPTER III

INSTRUCTIONAL DESIGN

Learner Analysis

Relevant Characteristics

Learner analysis identifies characteristics of the target audience which are relevant to the design and production of learning materials. Pupil age, attitude, subject matter competencies, educational background, and mental and physical abilities are some learner variables which shape the learning package.

This project, Microcomputers: How They Work, was developed in consideration of provincial school teachers or similar groups who seek a gentle introduction to microcomputers, their make-up, function, and application in educational settings.

Age, Maturity, and Achievement

Most members of the target audience will be elementary or secondary school educators with varying post secondary education and teaching experience. Some will hold bachelor and/or graduate degrees, while others may be part or full time education students. The level of maturity is expected to be high as all learners will be of varying adult age.

Attitudes

Prior to the design and development of this package, the instructional developer probed the following question: What are some general attitudes held by Newfoundland educators toward microcomputers and associated technologies? The literature — both global and national — clearly demonstrates that school teachers presently are undereducated in this area and in many cases hold negative views of computers. This was delineated in an earlier section. Attitudes toward such a pervasive technology may be unfounded, yet firm, and in this instructional developer's view, require a sensitive, empathic treatment.

From this initial enquiry a second question was generated. What means may best modify knowledge and attitudes of this population? Further in this report is a thorough justification of the instructional design development and media selected. However, it was ultimately decided to utilize a visual slide/audiotape format coupled with a popular microcomputer system for instructional purposes.

Content Analysis

Two essential questions are addressed in the content analysis of an instructional package. What will the learners do to develop desired skills and concepts, and how will the instructional developer demonstrate that learners have acquired these? Such questions dictate examination of three sub-analyses. These are, (i) the prerequisite knowledge (entry behavior) learners should hold for full benefit of the package, (ii) the tasks, sub-tasks and concepts intended to be mastered and (iii) expression of these tasks and concepts in operational terms as behavioral objectives or outcomes.

Learner Entry Behavior and Requisite Knowledge

Microcomputers: How They Work is a learning package designed for microcomputer novices. No special skills or knowledge need be held by the audience, though post-secondary teacher education and experience may be an asset. Learners should possess normal visual, auditory, and motor capabilities coupled with affective domain attributes — a willingness to learn, for instance.

Task/Concept Analysis

This is a graphic display in hierarchy form of the tasks and concepts to be mastered by the learners. Task analysis begins with specifying the terminal (end) task/concept and further dividing it into supportive sub-tasks/concepts until learner entry behavior is reached. Figure 2, page 66 illustrates the task/concept analysis in graphic form.

Behavioral Objectives (Learning Outcomes)

These are statements in measurable terms of the behaviors to be demonstrated by learners following exposure to a learning event. The intended learning outcomes of Microcomputers: How They Work are listed below.

Given the appropriate instruction, the learner should be able to correctly identify through multiple choice identification, true/false selection, or state freely:

1. The meaning of output.
2. The meaning of input.
3. Some appropriate examples of output.
4. Some appropriate examples of input.
5. Input and output sources as features characteristic of all machines.
6. An appropriate machine language as a characteristic of all machines.
7. Instructions as one type of input required by machines.
8. The meaning of the term processor.
9. The processor as the central feature of any input-process-output device.
10. The work unit and the control unit as processor components.
11. The operation order of the components of an input-process-output device.
12. The computer as an input-process-output device.
13. Cost, size, and processing power as features which differentiate among computers.

14. A means by which input is entered into a computer.

15. The operation order of a microcomputer.

Criterion Test Items

Evaluating the instructional success of this package was through the use of criterion test items, which are derived from and directly relate to the stated behavioral objectives. For each objective there are two test items — constructed differently but measuring the same objective. Thus, there are 30 similar items for the pretest and posttest. Moreover, to reduce learner familiarity with the testing instrument, items have been rearranged on the posttest.

It should be noted, as well, that pretest items 10 and 24 (posttest items 11 and 13) representing objective 13 were disqualified from the formal assessment. Following evaluation, a cursory review of the posttest items confirmed the instructional developer's earlier belief that students might exchange misinformation between items 13 and 11. As this was the case, a revision of these test questions would be necessary. Chapter V holds a more detailed analysis of the formal evaluation. Finally, both evaluation instruments may be found in Appendix A.

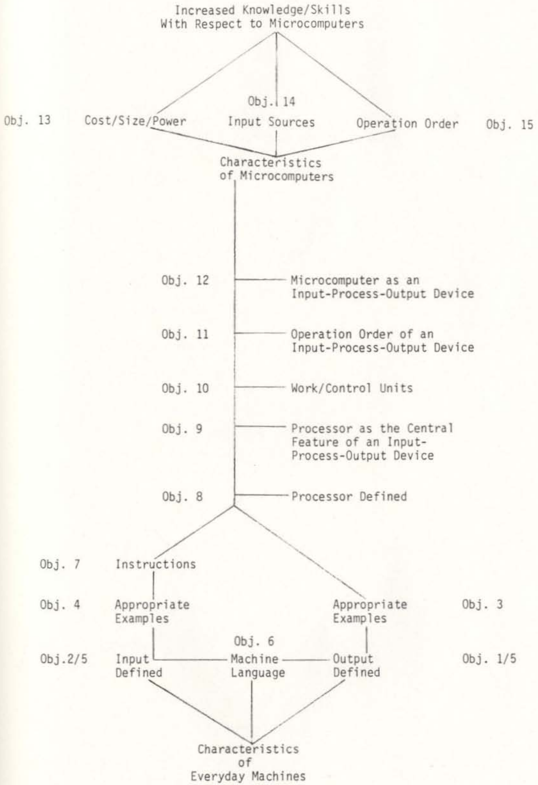

Figure 2. Task/Concept Hierarchy

Instructional Goal

Having experienced both the audio visual and microcomputer portions of Microcomputers: How They Work, 75% of the learners will have achieved a score of 75% or greater on the posttest evaluation instrument.

Rationale for Choice of Media

Recent literature supports frequent claims that instructional media, when properly matched with learning outcomes, has high potential for instructional success (Sive, 1979; Perry and Perry, 1981). Given this, as well as research supporting similar conclusions, then selecting appropriate media for teaching purposes should draw special consideration from the instructional developer.

Research Considerations

Ryan (1983) notes that past research demonstrates to a large extent the impact media can have on learner cognitive behavior and attitudes. His detailed review examines studies by educational technologists and psychologists on a variety of media, including overhead transparency, moving film, photographic slides, audio tape, and assorted visual displays. Findings suggest that media, when appropriately chosen and applied, can enhance instruction by providing stimulation, variety, and clarity in learning settings.

Further, the same author surveyed provincial educators and found media to be a desirable, if not necessary, component of teaching and learning, however, various media were viewed differently with respect to instructional utility and technical merits. For example, teachers preferred audiotape in conjunction with photographic slides or filmstrips to either of slides with script, audiotape only, slides only, or videotape. Videotape was not desirable because many educational institutions are still without a video cassette recorder and no universal format exists. 16 mm motion picture film was excluded from Ryan's survey due to inherent technical impracticalities.

Given the academic and professional similarities between educators Ryan surveyed and those this project involved it is reasonable to assume this group had very similar preferences with respect to educational media.

Instructional and Technical Considerations

In any systematic selection process for media, however, other variables, besides research and surveys of teacher/ learner preferences, play important roles in media consideration. Some of these variables include media attributes — motion, color, pacing, random access, and sensory modes (Thiagarajan, Semmel, Semmel, 1974), the nature of learning outcomes (cognitive, affective, psychomotor), instructional strategy needs, learner characteristics (abilities, disabilities, audience size, age, maturity, and attitudes), media familiarity and availability, facilities, costs, ease of use, production, duplication and distribution concerns.

For this learning package, potential instructional media for audio and visual display required the following capabilities:

Still Visuals and Pacing: These attributes provide for instructor control of content delivery. This was an important consideration since the presentation should be paced according to learner needs. Also, since many of the visuals are graphic displays, motion, as provided by moving film, would be unnecessary.

Random Access: Needed, as well, was a medium permitting easy access to particular sections of the content. This is useful for review purposes.

Behavioral Objective Considerations: A medium which promotes learning was critical as much of the package relates to cognitive outcomes.

Color. Color was required to help differentiate among the various parts of the operation chart. Also, it adds visual interest to the graphics and photographs.

Sound. Audio capability was a vital requirement needed to augment the visual display.

Other Considerations

The instructional developer considered several other criteria prior to media selection. These included a need for ubiquitous, familiar media which permit ease of use and are applicable to large groups. Equipment, production, duplication, and dissemination costs should be low. Given the nature of the content and how swiftly computer technology changes, revision and updating of material should be inexpensive and uncomplicated.

For Test Challenge, the microcomputer component, other criteria were considered. These included:

Programming Ease. A common high level language would permit effective, yet relatively simple design, development, and implementation of software.

Large Memory. 48 K or larger random access memory was needed to accommodate the program's information and data.

Hardware Considerations and Costs. Microcomputer costs vary considerably depending on system complexity. Initially, the intention was to utilize a relatively inexpensive but capable unit with printing capacity, acceptable monitor resolution, high data retrieval, disc drive function, and swift response ability.

Availability of Equipment, Service and Facilities. In the hope that Microcomputers, How They Work is utilized by provincial school boards or the Department of Education, service, technical advice, and supportive hardware should be available.

Decision

In light of these many considerations for media selection, a 35 mm visual slide/audio tape format in conjunction with a Radio Shack Model III microcomputer system was selected on the following instructional and technical merits.

Instructionally, 35 mm positive transparency meets the need for a still visual medium useful with large groups and providing random access to any portion of the program. Pacing instruction to suit learner needs is an inherent advantage as is the delivery of clear, vivid, color visuals. Further, recent evidence suggests that still visual media promote cognitive learning (Sive, 1979).

Technically, production, duplication, revision, distribution, and use of both media are relatively inexpensive and simple processes. Finally, audio cassette units and slide projectors are widespread — found in most, if not all, educational institutions.

A Radio Shack Model III microcomputer system was selected on the bases of similar instructional and technical reasons. Firstly, the Model III system provides for 48 K or larger random access memory, typing ability, disc drive service, programming in BASIC, acceptable monitor resolution, efficient data processing and information retrieval. As well, Radio Shack retail outlets are found province-wide providing equipment, service, and technical advice, if required.

CHAPTER IV

DEVELOPMENTAL PROCEDURES

Design and Production

The decision to design, produce, and disseminate a learning package in microcomputer operation and applications was made in light of a need for materials which will effectively introduce some educators and other computer novices to a pervasive technology.

Therefore, the instructional developer, in association with his advisors, initiated project development by identifying knowledge, skills, and attitudes which should be held by our educators, isolated priorities, and stated these as intended learning outcomes.

With the goals of the package identified, learner needs considered, and appropriate media chosen, the storyboard (a visual display of instructional events) and a script were created over a period of several months. During this time the content, style of presentation, audio and visual instructional sequences and strategy were continuously evaluated, altered, and edited until a professional, polished, and effective package emerged. Following these initial design stages, graphics were produced, photographs taken, the audio segment recorded, and the microcomputer program finalized. Technical information on production techniques and materials may be found in Appendix D.

Throughout the design and developmental stages the instructional developer's intent was to create a learning package which approaches the topic of microcomputers in an informal, non-technical manner, avoiding the use of jargon and tailoring the content to the audience's characteristics. For the audio visual portion, it was felt that an effective and novel approach would parallel microcomputer operation with everyday home appliances such as washers, stereos, shavers, etc. The intent of this comparison is to demonstrate that microcomputers operate on similar functional principles and hence are operationally no more complex than domestic machines. Following is the instructional sequence of the audio visual portion.

Introductory visuals. Several slides of children using a microcomputer provides a gentle introduction to the program. Appropriate music is supplied.

Slides 1-7. The viewer is given a brief overview of differences between yesterday's, today's, and tomorrow's classrooms.

Slides 8-11. The microcomputer is now identified as an integral part of today's and particularly tomorrow's classroom.

Slides 12-14. Microcomputers and household appliances are compared as operationally similar input-process-output devices.

Slides 15-18. The concept of output is introduced and defined using appropriate examples.

Slides 19-22. The concept of input is introduced and defined using appropriate examples.

Slide 23. Input and output are identified as common features of all machines.

Slides 24-27. At this point, the notions of a machine language and instructions are presented through the use of amusing, informal cartoons.

Slides 28-30. Processing the input via instructions and the concept of a machine as a processing device are hilited.

Slides 31-35. The processor as the central feature of any machine is noted, as are its components - the work and control units.

Slide 39. For summative purposes the overall machine operation model is displayed.

Slide 40. With the general concepts of input-process-output established the microcomputer is introduced as a processing machine functioning on similar operations.

Slide 41. Characteristics of microcomputers are features - its portability, low cost, and capability.

Slides 42-43. Larger computers and their inherent advantages over smaller micros are explained.

Slide 44. The keyboard is featured as a major input device.

Slides 45-47. Instructions in the form of a hard copy computer program using specialized language (BASIC) are featured. A display on the monitor demonstrates the output desired - a map of the island of Newfoundland.

Slide 48. The principles of machine operation are reviewed using the machine model display.

Slides 49-53. For closure, some photographs of children interacting with a microcomputer are presented followed by the credits.

As stated previously, a microcomputer program, Test Challenge, completes the learning package, Microcomputers: How They Work. It is designed to supplement the audio visual portion of the materials and assist with the realization of cognitive and affective outcomes by providing "hands on", manipulative microcomputer experience.

Throughout the development of this section, the intention was to demonstrate simultaneously the microcomputer's technical capabilities as an information processor and its merits as a teaching/learning device. To accomplish this, yet avoid "electronic page turning", a testing instrument in game format was designed. The decision to combine these two very different concepts was based on a perceived need to provide computer novices with a powerful introduction to computing - one which shows the microcomputer as a friendly, applicable, capable, and interesting product of modern science.

Given the necessity to support the audio visual presentation, yet provide a manipulative experience significantly different, a decision was made to retest the content viewed earlier using a familiar application of computers - gaming. This application has been shown to boost both motivation and learning (Braun, 1984). Further re-testing encourages recall of previously learned material.

The microcomputer component, Test Challenge, provides an opportunity for "hands-on" experience, augments the audio-visual portion and demonstrates the sophistication, capability and operation simplicity of the microcomputer as well as its utility as an agent for testing, teaching, and learning.

Test Challenge, however, is not intended to be an intense formal evaluation by the microcomputer of earlier learned material. It merely provides the user with an opportunity to work the computer and at the same time attempt to answer correctly 28 test items (similar in content and format to the pre-test) within a selected time frame — either 3 minutes (the expert level), 4 minutes (the intermediate level) or 5 minutes (a beginner's level). All items are either true/false or multiple choice and may be answered by selecting the correct option. Feedback is provided for response correctness but answers are not given — the learner must repeat the game and attempt particular items again. Of course, there is no requirement to complete a game, as he may exit any time — either to begin anew or end the session.

Following the microcomputer sitting, a hard copy of all events (the number of attempts, scores, time requirements, level selection, and right/wrong data) is typed by the printer unit and available for examination by the user.

CHAPTER V

EVALUATION

Background

Microcomputers: How they work is designed to assist provincial educators and other publics in their quest for fundamental knowledge and skills in microcomputer operation, function, and application.

To achieve these goals, the materials were developed over a considerable time period, continuously being revised and upgraded by the instructional developer on the advice of his supervisors, the expert appraisors, and the target audience. Upon completion, they were subjected to a thorough evaluative procedure.

The sample target population - thirty-three elementary school teachers - were seen as a valuable testing audience for two reasons. Firstly, none had recent formal experiences with computer facilities or instruction. Therefore, it was reasonable to assume they were mostly without the body of knowledge the package would impart. Secondly, as educators, their professional training and skills provided them with useful evaluation techniques to critically appraise the program's content delivery, instructional strategy, and overall effectiveness. Feedback in these areas would provide the instructional developer with information as to the program's ability to acceptably improve the audience's knowledge in microcomputers, and remove the mystique or misunderstandings which may exist among the learners.

Evaluation Design

For evaluation purposes, the selection of an appropriate evaluation design is perhaps the single most important decision confronting the instructional developer, as a qualitative package evaluation must ultimately validate the materials' instructional effectiveness.

Presently, several designs are available to the educational researcher, however, a widely applied scheme is the one-group pre-test-treatment-post-test design, whereby a traget audience is examined for pre-experimental knowledge or behavior, exposed to some treatment and re-tested to measure learning gains made, if any, from the exposure. Graphically, the process may be displayed as follows:

0 ————	X ————	0
the audience is examined	the audience is exposed to treatment	the audience is re-examined

Aside from those variables which can jeopardize the internal validity of the instructional package (history, maturation, testing, instrumentation and so on...), the one-group design is useful particularly for short instructional modules since many of the invalidating factors mentioned previously are controlled.

Evaluation Procedures

Thirty-three elementary school teachers, generally unaware of computers on a formal basis (courses, inservice classes, and so forth) first completed test instrument I (herein called the pretest) which determined their knowledge of the material to be presented. After completing this task, all candidates viewed the slide-tape component. Following this, subjects were given the opportunity to engage in a computer manipulation activity by playing Test Challenge - the microcomputer component of the package. Having interacted with the computer, the learners, if they desired, were permitted to view again the audio-tape segment or directly complete test instrument II (herein called the posttest) and an appraisal questionnaire which would provide broad feedback pertaining to the nature of the package. With these activities completed, evaluation by the learners was finalized. Next, it was necessary to collect the data, subject it to statistical measurements, and attempt to determine the package's effectiveness in addressing the intended learning outcomes.

Results and Analyses

Determining the effectiveness of learning materials demands a variety of tests to be performed on data retrieved from evaluation procedures. Such measurements largely reflect the breadth and depth of learning and assist in determining the origin of instructional gains.

As stated earlier, the sample target audience, largely unfamiliar with computers and computing, was tested prior to instruction, exposed to the learning package, and re-examined to measure instructional outcomes. Data retrieved from both testing procedures were examined via various statistical methods, including a comparison of group mean scores using the t statistic and an item analysis, to determine the value of the test instrument and the statistical significance of improvements which may, in turn, reflect the value of the test instrument.

The T Statistic

The t statistic is a useful determinant of mean significant improvements between populations tested before and after some treatment. By examining the differences between all pairs of data, the instructional developer hopes to draw a conclusion about the effectiveness of the treatment. A statistically significant improvement suggests gains due to the package and not the result of chance.

The formula used to calculate and compare mean scores of the dependent observations was ....

$$t = \frac{\bar{X}d}{S\bar{x}_d}$$

.... where $\bar{X}d$ is the mean difference between paired observations and $S\bar{x}_d$ is the standard error of the mean difference. Should the computed value be less than or equal to the critical region then one can assume no statistically significant difference exists between the two groups. Table 1 summarizes the results of this test.

Table 1

Results of Pretest and Posttest Analysis Using the T Statistic

	Learner Population (N)	Mean (M)	Standard Deviation	Computed "t" value
Pretest	33	63.40	2.30	10.60
Posttest	33	88.20		

df = 32 $p < .01$

The critical value is 2.75. 10.60 exceeds this value, thus demonstrating a statistically significant difference at the .01 level between the mean scores of the pretest and the posttest. Given this, one may assume the package was responsible for the improvement.

Item Analysis

This analysis individually examines each item, the objective it represents, and assesses the realization of objectives by the learners. Such an assessment is valuable because problems or difficulties inherent in the package, the test instrument, or the learners may be exposed.

Specifically, three sub-analyses comprise the Item analysis. They are: The Z Statistic (Z), the percentage of successful students on posttest items, and an index of success. Results of these analyses may be found in Table 2, p. 88.

The Z Statistic

A widely applied statistic in education and psychology, the Z statistic is useful for measuring significant differences between individual scores prior to and following instruction. Further, the test will determine the likelihood of posttest improvements due to chance or a result of learning through the package. The Z statistic for correlated (dependent samples) is ...

$$Z = \frac{d - a}{\sqrt{d + a}}$$

where 'a' reflects the number of learners who scored incorrectly on the pretest but correctly on the posttest and 'd' reflects the number of students who scored correctly on the pretest but incorrectly on the posttest.

Of the 28 items examined, 13 indicate gains statistically significant at, or greater than, the 95% confidence level. Ten of the 14 objectives were represented by at least one corresponding test item which was statistically significant (Recall that items 10 and 24 were disqualified from evaluation and thus determining learning gains for objective 13 was not possible.). Furthermore, 24 of 28 questions reflect some degree of improvement between pretest and posttest. However, because the sum of 'a' and 'd' does not equal or exceed 10 for several items, Z scores could not be reliably computed. Hence, determining statistically significant or insignificant findings for pretest items 2, 4, 6, 7, 9, 11, 15, 16, 19, 21, 26, 27, and 29 was not possible. These have been identified with the initials 'ND' meaning 'not determined'. Also, of this group are items 7, 9, and 16 which reflect performance regression between both tests for the majority of learners; that is, the learners appear to have performed better on the pretest than after treatment with the learning package. Again, because of a data shortage for these items, Z scores were not determined, thus preventing further conclusions to be drawn.

Discussion

A detailed examination of learner outcomes has revealed findings of consequence to the instructional developer. For example, while pupils broadly demonstrated statistically significant learning gains for the majority of objectives, some learners displayed previous knowledge and understanding of certain outcomes. This may be seen with respect to objective 1 (the meaning of output, pretest items 1 and 29), objective 2 (the meaning of input, pretest items 15 and 27), and objective 11 (machine processing order, pretest items 16 and 2). (See page 64 for a list of behavioral objectives.) One may be inclined to consider objective 12 for this category, however, a closer examination of pretest items 7 and 19 reveals inconsistent learner performance for these questions representing that objective. For example, item 19 was answered correctly by 27 of 33 students prior to instruction. The remaining 6 scored correctly on the posttest for an achievement of 100% (see column 6, table 2, page 88). Yet, for pretest item 7 (posttest item 4) some students not only regressed between tests, but 23 selected the incorrect option D (A and C only) instead of E (all of the above). In this case, the instructional developer suspects the majority of learners were not cognizant that a microscope and lever balance are processors. Therefore, in consultation with his advisor, the instructional developer decided to replace distractor B (A microscope and a lever balance) with names of more familiar, everyday processors. This revision may be found on page 104.

The fact that students performed well for objectives 1, 2, 11, and 12 (item 19) was not surprising considering the widespread use and application of the terms input, output, and process coupled with some relatively uncomplex test questions.

In conclusion then, the analysis of Z scores identified many test items which reflect statistically significant and insignificant instructional gains as well as several item scores which must be considered statistically, nonsignificant due to inconclusive data. Ten of 14 behavioral objectives were found to be represented by at least one item demonstrating statistically significant learning. Finally, pretest items 7, 10, and 24 (posttest items 4, 11, and 13) have been revised accordingly.

Percentage of Successful Students

Shown in column 6 (see Table 2, page 88) are the results of a simple measurement to compare overall performance for each item and its corresponding objective. The percentage of successful students on posttest items is the quotient of the number of learners with a particular item correct and the total learner population (N). Using this statistic, 24 of 28 (86%) posttest items are answered correctly by more than 75% of the learners - meeting the criterion that at least 75% of the learners score correctly on 75% of the items.

Table 2

Summary of Differences Between Pretest and Posttest Items

1	2	3	4		5	6	7
Behavioral Objective	Pretest Item	Posttest Item	Number of Successful Students		Difference Between 'a' and 'd' Z	% of Successful Students on Posttest	Success ⧣ Index
			'a'	'd'			
1	1	7	7	3	-1.265	.919	.571
11	2	23	5	0	ND	1.00	1.00
7	3	17	11	3	-2.133*	.636	.335
14	4	14	2	1	ND	1.00	1.00
9	5	5	14	4	-2.380**	.737	.571
6	6	3	4	0	ND	1.00	1.00
12	7	4	1	7	ND	.090	⧣
10	8	28	24	3	-4.030**	.818	.785
3	9	10	1	4	ND	.787	⧣
13	10	11	⧣	⧣	⧣	⧣	⧣
5	11	12	0	0	ND	.969	.750
4	12	15	23	0	-4.791**	.939	.970
8	13	22	10	0	-3.125**	.909	.769
14	14	8	19	1	-4.010**	.939	.875
2	15	24	2	0	ND	1.00	1.00
11	16	29	0	2	ND	.909	⧣
3	17	2	20	0	-4.464**	.909	.875
6	18	18	20	1	-4.139**	.909	.864
12	19	19	6	0	ND	1.00	1.00
7	20	1	9	4	-1.388	.484	.260
15	21	30	6	1	ND	.969	.833
9	22	25	10	2	-2.305*	.848	.61[illegible]
5	23	27	16	0	-4.000**	.939	.894
13	24	13	⧣	⧣	⧣	⧣	⧣
8	25	6	15	0	-3.870**	.818	.750
4	26	21	4	3	ND	.969	.875
2	27	26	4	0	ND	.969	.833
10	28	16	9	1	-2.531*	.818	.538
1	29	20	6	1	ND	.969	.857
15	30	9	30	0	-5.474**	.969	.966

* - $p < .05$

** - $p < .01$

ND - Not Determined

⧣ - Disqualified From Analysis

'a' - Number of learners who scored incorrectly on pretest but correctly on posttest

'd' - Number of learners who scored correctly on pretest but incorrectly on posttest

⧣⧣ - The Success Index for pretest items 7, 9, and 16 (posttest items 4, 10, and 29) was not determined since 'd' exceeds 'a'.

Success Index

A measure of the extent with which learning occurred because of exposure to instruction may be found by calculating the success index of posttest items. The formula is....

$$\frac{\text{Number of correct scores on the posttest (a)} - \text{Number of correct scores on the pretest (b)}}{a - b + \text{maximum possible number of responses} - b}$$

The quotient is a measure of scores reflecting improvement prior to, and following instruction. A typical calculation follows.

Objective 10 - Pretest item 8; posttest item 28

$$\frac{27 - 5}{(27 - 5) + (33 - 27)}$$

$$= \frac{22}{28}$$

$$= .785$$

The success index of .785 implies that instructional gains on 78.5% of these items was, in all likelihood, due to the package's effectiveness and not previously held knowledge, as demonstrated by the pretest score.

Results of the Learner-Computer Interaction

As stated earlier, 33 candidates were given the opportunity to interact with a Radio Shack TRS-80 Model III microcomputer following the audio-visual presentation. The sitting involved playing Test-Challenge - A friendly, informal, competitive game whereby the learner answers questions based on the subject matter viewed in the audio-visual presentation. To meet the challenge, learners select an appropriate level of expertise matched with specific time frames (either 3, 4, or 5 minute periods) and attempt to score highly (an 80% criterion test level) within the selected limited period.

While all results were made available to the learner, it was not statistically valid for inclusion here as candidates could freely experiment, probe, and examine the program and hardware during, or following, each game. Results of this interaction are, unfortunately, not useful for statistical measurement and represent only the sequence of events and improvement in scores made by the pupil over a 15 minute period. A typical interaction may have progressed with the learner attempting several items on a first try, perhaps realizing the informality of the game and then, without finishing, initiating a new challenge. For example, student 12 answered correctly 14 of 15 items on the first attempt, yet yielded only a 50% score (see table 3 following).

Her record of events is included to demonstrate that generally learners were willing to engage in gaming with the computer without fear of time constraints and formal evaluation via computer. Similarly, some students who appeared to be keenly interested in the microcomputer continued to play and improve their scores until an acceptable level was reached.

Table 3

Summary of Test Challenge Statistics for Student 12

NAME	TRY #	% RIGHT	TIME	LEVEL	R	W
LINDA	1	50	4:39	B	14	1
LINDA	2	85	3:38	I	24	4
LINDA	3	89	3:30	E	25	1

Examination of these scores reveals data that is relevant to the acquisition of the package's cognitive skills and objectives. Equally important, however, is the development of appropriate attitudes - a primary objective of this package.

To measure feelings harbored by the representative audience and collect feedback regarding the instructional and technical merits of the package, as well as its flaws, a program appraisal questionnaire was distributed and completed by each teacher..

Teacher Evaluation and Feedback

This evaluation form was completed by all candidates following the posttest. A summary of mean ($\bar{X}$) responses may be found on page 100. Clearly, comments and broad feedback overwhelmingly support the whole package.

Initially, many learners were apprehensive about the microcomputer, but within the first introductory frames they relaxed and felt more at ease. In fact, several students were keen to investigate the disk drive unit and internal machine parts. Item 14 of the questionnaire encouraged free student response. Included are these comments.

> ...Very enjoyable....Very interesting... Computer difficult to read...Fun great, well done. Get people familiar with computers. Demystify...interesting... fun...excellent...very interesting...

Indeed, teachers' evaluating the total instructional package were impressed with its design, technical production, and presentation of content. Some expressed interest in obtaining a copy for school use.

Evaluation by Content and Teaching Specialists

Assessing newly designed instructional materials requires a thorough evaluation of their capability to meet the need for which they are designed and, if necessary, to modify and improve them until a desirable product is attained. Given this, a thorough qualitative evaluation of content correctness, presentation style and delivery, media usage, and goal achievement should be performed by knowledgeable experienced evaluators.

Expert Appraisal

For the purposes of this project consultants from the Science and Media Divisions of the Newfoundland Department of Education formally evaluated the package. Given their background and familiarity with microcomputers and instructional media, design, and development, the instructional developer was confident of their capability and competence to evaluate the package for instructional effectiveness, appropriateness, and its potential for widespread dissemination.

Following exposure to the whole package (the audio-visual component and the microcomputer sitting) the appraisors and the instructional developer evaluated in an informal atmosphere of discussion, the instructional and technical merits of the package, some modifications for improvement, and its potential utility by the provincial Department of Education to assist with its computer awareness plans.

An itemized questionnaire was completed by the appraisors to provide useful feedback. A summary of the mean findings may be found on page 102. Item 18 provided an opportunity for them to comment freely about the package's merits and drawbacks.

Reaction to the Audio and Visual Materials

Generally, the appraisors were pleased with the package's technical production, style of presentation, content accuracy, and delivery. Particularly, the graphics and photography were of a professional calibre - technically well prepared and instructionally effective. As subjects, the school children were natural and uninhibited. The reviewers praise for the operation order chart was particularly high as was the use of humor in art work to demonstrate the effects of an incorrect order of operations.

In their view, the audio portion was acceptable but less pleasing. Concerns were expressed about the narrator's presentation speed and accent, though technically the recording was of acceptable quality.

Suggestions for Modification to the Audio and Visual Materials

1. The critics felt the inclusion of a photograph depicting a microcomputer's processor would add technical and instructional impact to the audio-visual portion.

2. There was some discussion about re-taping the audio portion using another narrator, however, this was not seen as a major flaw with the program.

Reaction to the Microcomputer Component of the Package

Using the microcomputer as an integral part of the learning package was applauded by the reviewers. In their view, it is a fresh approach to introducing microcomputer form and function and has good potential for realizing the package's goals.

Aside from a technical difficulty with the printer unit and some concerns about the microcomputer program, the critics felt the microcomputer sitting was worthwhile, providing a personal "hands on" opportunity to interact with the computer.

Suggestions for Modification to the Microcomputer Component of the Package

The reviewers expressed the following concerns and suggested some modifications prior to dissemination. These included:

1. Re-arranging some introductory text information into a more manageable, easy to read format. They felt several frames contained an excess of information which creates reading difficulty.

2. Including in the introductory text material more explicit instructions regarding the delivery of a response. Specifically, an instruction should state clearly whether the user must ENTER a response or PRESS ANY KEY.

3. Extend the "extra time" period. When, during play of Test Challenge, the allotted time expires, a grant of one minute extra is provided. The critics suggested this allotment is inadequate and should be increased by an additional sixty seconds.

Other Recommendations

The reviewers were generally pleased with Micro computers: How They Work and following modification recommend its distribution to school boards throughout the province. They are also anxious to develop a package similar to this, but modified to suit elementary and perhaps, junior high school students.

Instructional Developer's Reaction to the Expert Appraisal and Modifications Made

Effective evaluation procedures entail the sensitivity of the instructional developer to a critical analysis by experts and when deemed necessary, modify materials until an acceptable, polished form results.

With this in mind, the instructional developer felt the following alterations were necessary to improve the package.

The Microcomputer Component (Test Challenge)

1. Introductory text material was condensed and re-structured to permit easier reading on the video display unit (VDU). Full paragraphs have been divided into smaller, more manageable units of text.

2. Instructions stating more clearly the procedure for responding to questions were added to the introductory text information. For example, line 960 of the text asks the learner "will we continue?". Initially, instructions were not provided directing the manner to respond - either YES (Y) or NO (N) and if the ENTER command is necessary. In the upgraded version the learner is told to select either option and use the ENTER key.

3. An additional sixty seconds was added to the program's extension time which comes into effect when the initial time has expired. The extended time grant is now two minutes which, the instructional developer and critics feel, is an adequate time period to complete Test Challenge.

The Audio-Visual Package

No major modifications were made to the audio-visual materials. Essentially, the criticisms were considered to be minor by all parties and time-consuming alterations could not be justified by instructional gains. For example, the narrator's non-local accent should not inhibit transmission of information if the material is clearly delivered in a professional manner. It is noteworthy that none of the thirty-three learners commented negatively about any portion of the audio delivery and, in fact, rated the narration a mean of 4.72 on a 5 point scale.

The instructional developer agrees that a microcomputer processing unit would be instructionally useful, however; such a change would entail including an additional slide and re-taping the script with further statements noting the component. Considering all test items relevant to the processor, its function and its make-up (Objectives 8, 9, 10) have shown learning gains (several statistically significant) and that the inclusion of such a component is, as the appraisors agree, of only minor importance, the audio and video portions were not altered to include a microcomputer processing unit.

Finally, to ensure the audio-visual production reflects state-of-the-art hardware an additional slide of a modern popular microcomputer is included at the program's introduction.

Conclusions

The formal evaluation of Microoomputers: How They Work reveals broad instructional gains made by the representative target audience with the instructional goal that 75% or more of the learners achieve a raw score of at least 75% having been met. The T test is significant at the .01 level and test items of eight objectives show statistically significant gains between preprogram and postprogram tests. Further, all remaining objectives are represented by items demonstrating improvement of varying degrees.

Overall, the appraisors and target audience representatives were impressed with the concept, design, production, and content delivery of Microcomputers: How They Work. These evaluators feel it has merit and applicability, and with minor modificiations should prove to be a valuable learning aid.

Summary of Target Audience's Review

Program Appraisal - Questionnaire

Directions: Rate the instructional program by circiling the number on the scale which best represents the way you feel for each question.

	Question		1	2	3	4	5		Mean Rating
1.	How would you rate the organization of the materials?	disorganized			(1)	(6)	(26)	organized	4.75
2.	In your view, how difficult was the program?	easy	(9)	(13)	(11)	(2)		hard	2.24
3.	How about the length of the program?	short	(8)	(7)	(18)			long	1.21
4.	To what degree was the information clearly presented?	unclear				(6)	(27)	clear	4.81
5.	How would you rate the level of language?	easy	(22)	(7)	(1)	(2)		hard	1.42
6.	How would you rate the provision of feedback in the computer program?	not enough		(1)	(1)	(14)	(17)	enough	4.42
7.	How would you rate the provision of review in the audio-visual program?	not enough			(5)	(12)	(16)	enough	4.33
8.	How would you rate the quality of the visual material?	poor			(1)	(10)	(22)	good	4.63
9.	How would you rate the quality of the audio material?	poor				(9)	(24)	good	4.72
10.	How would you rate the style of presentation?	dislike			(3)	(8)	(22)	like	4.57

Summary of Target Audience's Review (Continued)

					Mean Rating
11.	Is there a need for more instructional materials of this kind?	not at all	1 2 3 4 5 (12)(8)(13)	much	4.54
12.	To what degree would teachers be willing to use this type of program?	not at all	1 2 3 4 5 (1)(4)(8)(20)	much	4.42
13.	How would you rate the overall effectiveness of the program?	ineffective	1 2 3 4 5 (1)(2)(6)(24)	effective	4.60
14.	Other Comments?				

Summary of Critics' Review

Program Appraisal - Questionnaire

Directions: Rate the instructional program by circiling the number on the scale which best represents the way you feel for each question.

								Mean Rating
1. How would you rate the organization of the materials?	disorganized	1	2	3	4	5 (2)	organized	5.0
2. In your view, how difficult was the program?	easy	1	2	3 (2)	4	5	hard	3.0
3. How about the length of the program?	short	1	2 (2)	3	4	5	long	2.0
4. To what degree was the information clearly presented?	unclear	1	2	3	4 (1)	5 (1)	clear	4.5
5. How would you rate the level of language?	easy	1	2	3 (2)	4	5	hard	3.0
6. How would you rate the provision of feedback in the computer program?	not enough	1	2 (1)	3 (1)	4	5	enough	2.0
7. How would you rate the provision of review in the audio-visual program?	not enough	1	2	3 (1)	4 (1)	5	enough	3.5
8. How would you rate the quality of the visual material?	poor	1	2	3	4 (1)	5 (1)	good	4.5
9. How would you rate the quality of the audio material?	poor	1	2 (1)	3	4 (1)	5	good	3.0

Summary of Critics' Review (Continued)

									Mean Rating
10. How would you rate the style of presentation?	dislike	1	2 (1)	3	4	5 (1)	like		3.5
11. Is there a need for more instructional materials of this kind?	not at all	1	2	3	4 (2)	5	much		4.0
12. To what degree would teachers be willing to use this type of program?	not at all	1	2	3	4 (2)	5	much		4.0
13. How would you rate the overall effectiveness of the program?	ineffective	1	2	3	4 (2)	5	effective		4.0
14. How useful is the computer component in assisting with the instructional goals of the package?	not useful	1	2	3 (1)	4	5 (1)	very useful		4.0
15. How would you rate the quality of the computer program?	poor	1	2 (2)	3	4	5	good		2.0
16. How accurate is the information?	inaccurate	1	2	3	4	5 (2)	accurate		5.0
17. To what degree would teacher trainers be willing to use this program?	not at all	1	2	3 (1)	4 (1)	5	much		3.5

18. Other Comments?

Revisions to Pretest and Posttest Items of the Evaluation Instrument

The following test items have been revised as recommended by the expert appraisors.

Objective 12. Pretest item 7 / Posttest item 4

Original item

Which of the following operate on the principle of machine operation?

☐ A. A stereo, washer and an electric range

☐ B. A microscope and a lever balance

☐ C. A microcomputer and a food processor

☐ D. A and C only

☐ E. All of the above

Revised item

Which of the following operate on the principle of machine operation?

☐ A. A stereo, washer and an electric range

☐ B. A toaster and an automatic coffee percolator

☐ C. A microcomputer and a food processor

☐ D. A and C only

☐ E. All of the above

Objective 13. Pretest item 10 / Posttest item 11

Original item

Computers are usually differentiated on the basis of cost, transistor size, and paper tape processing time.

☐ True

☐ False

Revised item

Computers are usually differentiated on the basis of cost, size, and processing time.

☐ True

☐ False

Objective 13. Pretest item 24 / Posttest item 13

Original item

Three fundamental features which may differentiate computers are:

(i) cost

(ii) __________

(iii) __________

Revised item

Three fundamental features which may differentiate computers are:

☐ A. Size, input, and operation order

☐ B. Cost, operation order, and size

☐ C. Processing time, size, and co

☐ D. Operation order, cost, and proce sing time

CHAPTER VI

CONCLUSIONS, RECOMMENDATIONS, IMPLEMENTATION

Conclusions

Microcomputers: How They Work has been locally designed and produced to meet a need by provincial educators for suitable and effective computer based learning materials in microcomputer form, function, and utility.

To determine its capability for meeting this need, the package was evaluated formally by a representative group of the target audience. Results of this evaluation revealed cognitive learning gains and positive affective changes with respect to microcomputers. As well, some test imperfections were identified which required improvement revisions. An assessment was also carried out by expert appraisors from the Provincial Department of Education who made several recommendations for improvement but overall found the package to be a valuable learning resource. Their recommendations were acknowledged, and following further alterations the materials were readied for duplication, packaging, and distribution.

Recommendations

The instructional developer recommends immediate distribution and use of Microcomputers: How They Work for preservice, inservice, and extraservice courses in educational computing for educators unfamiliar with this technology. It may be used as a stand alone instructional package or in conjunction with other materials - perhaps one or more of the Fast Forward videotapes, if available.

Furthermore, it is recommended that an additional package be designed and produced to supplement this unit. While Microcomputers: How They Work provides a broad overview of microcomputer architecture, function, and teaching utility, another package could explore in greater detail how this resource may be used in teaching. Also perhaps some methods for development of appropriate microcomputer based learning materials could be described.

Implementation

As suggested by many teachers who evaluated the package, the expert appraisors and staff members of the Learning Resources Division, Faculty of Education, Memorial University, the instructional developer recommends distribution of Microcomputers: How They Work to all Provincial school board offices, the Division of Instruction, Newfoundland Department of Education, the Instructional Materials Centre, Pleasantville, and the Centre for Audio Visual Education (CAVE), Memorial University.

Finally, it is the instructional developer's desire that Microcomputers: How They Work be utilized fully by teacher educators and education decision makers to improve provincial teachers' knowledge with respect to microcomputers and their applications in teaching and learning settings.

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APPENDICES

APPENDIX A

Test Instruments and Answer Key

INSTRUCTIONS

Complete the following test as follows. For multiple choice and true or false items identify the correct response by ticking the appropriate selection (✓). For free-response items (______) complete the space with the correct answer.

TEST 1

(PRETEST)

M.U.N. # ____________

1. Output may be defined as:

   ___ A. Instructions or data which are entered into a machine and required by that machine for processing operations.

   ___ B. A peripheral device which delivers a hard copy of data or text information.

   ___ C. Those products arising from machines which perform processing operations.

   ___ D. Data stored on external devices and not immediately accessed by a machine.

2. The operation order of machines which perform operations is ____________ - ____________ - ____________.

3. Part of the input for all machines is in the form of commands or ____________.

4. Input is usually entered into a microcomputer through:

   ___ A. The keyboard.

   ___ B. The processor.

   ___ C. The control unit.

   ___ D. The video display unit.

   ___ E. Paper tape.

5. Consider the following:

   (i) An input unit.
   (ii) The machine language.
   (iii) A memory facility.
   (iv) The work and control units.
   (v) A binary digit.

Which of these is the central feature of an input-process-output device?

___ A. (i)

___ B. (ii)

___ C. (iii)

___ D. (iv)

___ E. (v)

6. An appropriate machine language is a common characteristic of all machines.

___ True.

___ False.

7. Which of the following operate on the principle of machine operation?

___ A. A stereo, washer, and an electric range.

___ B. A microscope and a lever balance.

___ C. A microcomputer and a food processor.

___ D. A and C only.

___ E. All of the above.

8. List the two main components of a processor.

1. ______________ 2. ______________

9. Consider the following events:

(i) Dirty clothes placed in a washing machine.
(ii) A thermometer indicates a temperature of 20°C.
(iii) The setting of a stereo's volume and tone controls.
(iv) Student marks appear on the display unit of a microcomputer.
(v) Electrical energy discharged from a generator.

Which of the above events are appropriate examples of output?

___ A. (i), (ii), (iii)

___ B. (i), (ii), (iii), (iv)

___ C. (ii), (iii), (iv)

___ D. (ii), (iv), (v)

10. Computers are usually differentiated on the basis of cost, size, and processing time.

___ True.

___ False.

11. Two features characteristic of all machines which perform operations are:

___ A. Some data and a coding device.

___ B. System commands and a time-sharing capability.

___ C. An input source and an output source.

___ D. A machine language and a batch processing capability.

12. An appropriate example of input for an "everyday" machine would be ______________________.

13. A processor is a device which:

___ A. Consists of instructions for solving a problem.

___ B. Changes input to output.

___ C. Forwards instructions to the control unit.

___ D. Preserves internally stored information.

___ E. Both C and D.

14. A ____________________ is generally used as a microcomputer input device.

15. Input may be defined as:

___ A. Those rules which specify exactly how an instruction is to be written.

___ B. A series of instructions within a program which performs a specific subtask of the program.

___ C. That instruction which activates the execution of a number of other instructions.

___ D. Any instructions, data, or materials entered into a machine and required by that machine for processing operations.

16. Consider the following machine operation terminology.

(i) Process
(ii) Input
(iii) Output

The operation order of a machine is:

___ A. (iii), (i), (ii)

___ B. (ii), (i), (iii)

___ C. (ii), (iii), (i)

___ D. (i), (iii), (ii)

17. An appropriate example of output from an "everyday" machine would be ________________________________.

18. Which of the following is characteristic of all machines which perform operations?

___ A. An appropriate machine language.

___ B. The capability of the user to interact with the machine.

___ C. Only one operation stage.

___ D. Handling large quantities of input.

19. The microcomputer operates on the principle of machine operation.

___ True.

___ False.

20. Which of the following may be classified as input?

___ A. A programming flowchart.

___ B. Machine instructions.

___ C. Processing power.

___ D. A keyboard.

___ E. Both A and D.

21. The operation order of a microcomputer is:

______________ – ______________ – ______________.

22. The central feature of a machine which performs operations is the:

___ A. Memory facility.

___ B. Control unit.

___ C. Processor.

___ D. Machine language.

23. Besides processing capabilities all machines are characterized by sources of ________________ and ________________.

24. Three fundamental features which may differentiate computers are:

___ A. Size, input, and operation order.

___ B. Cost, operation order, and size.

___ C. Processing time, size, and cost.

___ D. Operation order, cost, and processing time.

25. A machine which carries out the procedure of changing input to output is called a ________________.

26. Consider the following events:

(i) U.V. radiation emitted from a radiation source.
(ii) Water streaming into a hydroelectric plant.
(iii) An oven indicates 100^{o}C after proper control settings.
(iv) Automobiles arriving at the end of an assembly line.
(v) A daily intake of vitamins.

Which of the above events are appropriate examples of input?

___ A. (ii), (v)

___ B. (ii), (iii), (iv)

___ C. (i), (iv)

___ D. (iii), (iv)

___ E. (i), (v)

27. Instructions or materials which are entered into a machine and required by that machine for processing operations are known as ________________.

28. Consider the following machine components:

(i) An input unit.
(ii) An output unit.
(iii) A control unit.
(iv) A work unit.
(v) A memory facility.

Which of the above components constitute a processor?

___ A. (i), (iii)

___ B. (ii), (iv)

___ C. (i), (ii)

___ D. (ii), (v)

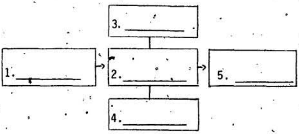
___ E. (iii), (iv)

29. Those products arising from machines which perform operations are called ______________.

30. Using the selection of microcomputer terminology provided, complete the following microcomputer operation chart by placing the correct term in the appropriate space.

Terminology

- Input
- Work Unit
- Disc Drive
- Run
- Output
- Processor
- Memory
- Control Unit



INSTRUCTIONS

Complete the following test as follows. For multiple choice and true or false items identify the correct response by ticking the appropriate selection ( ). For free-response items (______) complete the space with the correct answer.

TEST 2

(POSTTEST)

M.U.N. # ______________

1. Which of the following may be classified as input?

   ___ A. A programming flowchart.

   ___ B. Machine instructions.

   ___ C. Processing power.

   ___ D. A keyboard.

   ___ E. Both A and D.

2. An appropriate example of output from an "everyday" machine would be ______________________________.

3. An appropriate machine language is a common characteristic of all machines.

   ___ True.

   ___ False.

4. Which of the following operate on the principle of machine operation?

   ___ A. A stereo, washer and an electric range.

   ___ B. A microscope and a lever balance.

   ___ C. A microcomputer and a food processor.

   ___ D. A and C only.

   ___ E. All of the above.

5. Consider the following:

   (i) An input unit.
   (ii) The machine language.
   (iii) A memory facility.
   (iv) The work and control units
   (v) A binary digit

Which of these is the central feature of an input-process-output device?

___ A. (i)
___ B. (ii)
___ C. (iii)
___ D. (iv)
___ E. (v)

6. A machine which carries out the procedure of changing input to output is called a ____________________.

7. Output may be defined as:

___ A. Instructions or data which are entered into a machine and required by that machine for processing operations.

___ B. A peripheral device which delivers a hard copy of data or text information.

___ C. Those products arising from machines which perform processing operations.

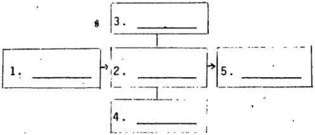
___ D. Data stored on external devices and not immediately accessed by a machine.

8. A ____________________ is generally used as a microcomputer input device.

9. Using the selection of microcomputer terminology provided, complete the following microcomputer operation chart by placing the correct term in the appropriate space.

Terminology

- Input
- Work Unit
- Disc Drive
- Run
- Output
- Processor
- Memory
- Control Unit



10. Consider the following events:

(i) Dirty clothes placed in a washing machine.
(ii) A thermometer indicates a temperature of 20°C.
(iii) The setting of a stereo's volume and tone controls.
(iv) Student marks appear on the display unit of a microcomputer.
(v) Electrical energy discharged from a generator.

Which of the above events are appropriate examples of output?

___ A. (i), (ii), (iii)

___ B. (i), (ii), (iii), (iv)

___ C. (ii), (iii), (iv)

___ D. (ii), (iv), (v)

11. Computers are usually differentiated on the basis of cost, size, and processing time.

___ True.

___ False.

12. Two features characteristic of all machines which perform operations are:

___ A. Some data and a coding device.

___ B. System commands and a time-sharing capability.

___ C. An input source and an output source.

___ D. A machine language and a batch processing capability.

13. Three fundamental features which may differentiate computers are:

___ A. Size, input, and operation order.

___ B. Cost, operation order, and size.

___ C. Processing time, size, and cost.

___ D. Operation order, cost, and processing time.

14. Input is usually entered into a microcomputer through:

___ A. The keyboard.

___ B. The processor.

___ C. The control unit.

___ D. The video display unit.

___ E. Paper tape.

15. An appropriate example of input for an "everyday" machine would be ______________________________.

16. Consider the following machine components:

    (i) An input unit.
    (ii) An output unit.
    (iii) A control unit.
    (iv) A work unit.
    (v) A memory facility.

    Which of the above components constitute a processor?

    ___ A. (i), (iii)

    ___ B. (ii), (iv)

    ___ C. (i), (ii).

    ___ D. (ii), (v)

    ___ E. (iii), (iv)

17. Part of the input for all machines is in the form of commands or ______________.

18. Which of the following is characteristic of all machines which perform operations?

    ___ A. An appropriate machine language.

    ___ B. The capability of the user to interact with the machine.

    ___ C. Only one operation stage.

    ___ D. Handling large quantities of input.

19. The microcomputer operates on the principle of machine operation.

    ___ True.

    ___ False.

20. Those products arising from machines which perform operations are called ______________.

21. Consider the following events:

(i) U.V. radiation emitted from a radiation source.
(ii) Water streaming into a hydroelectric plant.
(iii) An oven indicates 100°C after proper control settings.
(iv) Automobiles arriving at the end of an assembly line.
(v) A daily intake of vitamins.

Which of the above events are appropriate examples of input?

___ A. (ii), (v)

___ B. (ii), (iii), (iv)

___ C. (i), (iv)

___ D. (iii), (iv)

___ E. (i), (v)

22. A processor is a device which:

___ A. Consists of instructions for solving a problem.

___ B. Changes input to output.

___ C. Forwards instructions to the control unit.

___ D. Preserves internally stored information.

___ E. Both C and D.

23. The operation order of machines which perform operations is ________________ — ______________ — ____________.

24. Input may be defined as:

___ A. Those rules which specify exactly how an instruction is to be written.

___ B. A series of instructions within a program which performs a specific subtask of the program.

___ C. That instruction which activates the execution of a number of other instructions.

___ D. Any instructions, data, or materials entered into a machine and required by that machine for processing operations.

25. The central feature of a machine which performs operations is the:

___ A. Memory facility.

___ B. Control unit.

___ C. Processor.

___ D. Machine language.

26. Instructions or materials which are entered into a machine and required by that machine for processing operations are known as ______________.

27. Besides processing capabilities all machines are characterized by sources of __________ and __________.

28. List the two main components of a processor.

1. ____________________ 2. ____________________

29. Consider the following machine operation terminology.

(i) Process.
(ii) Input.
(iii) Output.

The operation order of a machine is:

___ A. (iii), (i), (ii)

___ B. (ii), (i), (iii)

___ C. (ii), (iii), (i)

___ D. (i), (iii), (ii)

30. The operation order of a microcomputer is

________________ - ________________ - ________________

Answer Key for Revised Test Instruments

Pretest

1. C
2. Input — Process — Output
3. Instructions
4. A
5. D
6. True
7. E
8. 1. Control Unit 2. Work Unit
9. D
10. True
11. C
12. (Answers will vary)
13. B
14. Keyboard
15. D
16. B
17. (Answers will vary)
18. A
19. True
20. B
21. Input — Process — Output
22. C
23. Input and Output
24. C
25. Processor
26. A
27. Input
28. E
29. Output
30. 1. Input 2. Processor 3. Control unit (or Work unit) 4. Work unit (or Control unit) 5. Output

Answer Key for Revised Test Instruments

Posttest

1. B
2. (Answers will vary)
3. True
4. E
5. D
6. Processor
7. C
8. Keyboard
9. 1. Input 2. Processor
   3. Control unit (or Work unit)
   4. Work unit (or Control unit) 5. Output
10. D
11. True
12. C
13. (i) Cost (ii) Size (iii) Processing Time
14. A
15. (Answers will vary)
16. E
17. Instructions
18. A
19. True
20. Output
21. A
22. B
23. Input — Process — Output
24. D
25. C
26. Input
27. Input and Output
28. 1. Control Unit 2. Work Unit
29. B
30. Input — Process — Output

APPENDIX B

Script

	VISUAL	AUDIO
1.0	MCU Children at microcomputer, facing camera.	Natural classroom sound - groups of children talking/working at a microcomputer.
1.1	MCU Children at microcomputer, backs to camera.	Natural classroom sound.
1.2	CU Child's hands on keyboard.	Natural classroom sound.
1.3	MCU Children at microcomputer, side-on, VDU etc. in view.	Natural classroom sound.
1.4	WS Classroom, children at various activities, microcomputer group in foreground, plus teacher attending to students.	Natural classroom sound...(fade)...(voice over)... "From the earliest and simplest of beginnings, the classroom has always played an important part in school learning. In many ways, this modern classroom is similar to those of the one-room schools at the turn of the century. What makes it especially different, though, is the range of learning aids now available to students."
1.5	MCU Children at listening center, other children with other media in background.	"For example, tape recorders, films, and television are a familiar part of many of today's students learning."

VISUAL		AUDIO
1.6	MCU Group of children around microcomputer, side-on.	"Many of today's students, and especially tomorrow's students, however, are going to encounter in their learning one of technology's latest innovations, the microcomputer"...(fade out) natural classroom sound...(fade in) music...
1.7	MCU Children at microcomputer; title--MICROCOMPUTERS: How They Work--supered over.	Music...(fade-down)...(voice over)..."This program, 'Micro-computers: How They Work,' is an introduction to microcomputer technology."
1.8	MUC Input-Process-Output Chart	"In this presentation you will see that a computer works on the same principle as many familiar and everyday machines around the home." ...(fade-up) music.
2.1	WS Classroom, children at various activities.	"Although many changes have taken place in the classroom, many things have changed in your own home, too."
2.2	3-part graphic: electric drill, shaver, hairdryer.	"It is now commonplace to use many kinds of machines. Some of the simpler ones include electric drills, shavers, and hairdryers."
2.3	3-part graphic: washer, stereo, electric range.	"Some of the more elaborate machines include washers, stereos, and electric ranges."

VISUAL		AUDIO
2.4	MCU Inside of washer, showing wiring, etc.	"Although these machines seem complicated with all their different parts, in fact they all have several basic things in common."
2.5	MCU Woman removing clothes from washer.	"One thing they have in common is that they all produce something. The washer, for example, produces clean clothes."
2.6	CU Woman removing cooked meal from range.	"The electric range gives us cooked food."
2.7	CU Man listening to stereo with headphones.	"The stereo gives us sound."
2.8	3-part graphic: 2.5, 2.6, 2.7, plus "OUTPUT" overlay.	"The products, the clean clothes from the washer, cooked food from the range and sound from the stereo arise from machines which perform operations. We call these products 'output'.
2.9	MCU Clothes in washer, woman putting in measure of washing powder.	"To get this output, something has to first be put into the machine. For the washer, you have to put in the clothes, soap, water, and then set the controls."
2.10	MCU Woman putting food into electric range.	"For the electric range, you have to put in the food and set the temperature and perhaps time controls."

VISUAL		AUDIO
2.11	MCU Man putting record onto record deck.	"For the stereo, you have to put on a record, for example, and once again set the controls; in this case, volume and tone."
2.12	3-part graphic: 2.9, 2.10, 2.11, plus "INPUT" overlay.	"The things which are put into each machine -- clothes, soap and water for the washer, food and temperature settings for the range and tone and volume settings for the stereo are examples of input. These sources of input are entered into and required by each machine for processing operations."
2.13	MCU INPUT and OUTPUT blocks of "machine model."	"All machines have these two features in common; they all require 'input', or what is put in, and they all give 'output', or what is produced, the actual output being dependent on the machine itself."
2.14	Same as 2.12.	"The 'input' required also depends on the machine, except that part of the input for all machines is 'instructions'."
2.15	Cartoon: woman giving nonsense instructions to washer, in desperation; puzzled machine.	"In a way, each machine has its own language; it can only accept certain instructions."
2.16	CU Hands setting dials on washer.	"For many machines, these 'instructions' are given by means of dials and switches."

	VISUAL	AUDIO
2.17	Cartoon: woman in panic, "tragic" output from washer.	"And it isn't enough to just throw switches and turn dials. Unless you give the 'right' instructions, or make the right settings, you will not get the output you wanted. A machine will only do what you tell it to do!"
2.18	INPUT — OUTPUT blocks of "machine model."	"But even supplying the right input is not enough. Something is needed to change the input to output — that something is the machine, itself."
2.19	INPUT — OUTPUT plus line drawings of washer, range, and stereo between INPUT and OUTPUT.	"In our examples, we have seen a washing machine which inputs dirty clothes and outputs clean clothes; a range, which inputs raw food and outputs cooked food; and a stereo which inputs records and outputs sound."
2.20	Same as 2.19 + overlay, "PROCESSOR", over line drawings of machines.	"In each case it is the machine which carries out the process of changing input to output. For that reason, each machine is a 'processor'."
2.21	INPUT — PROCESSOR — OUTPUT components of "machine" model.	"In fact, any machine that changes input to output is called a processor. The processor is the central feature of any input-output device."
2.22	Same as 2.4.	"Most processors have two parts. One of these is the 'work unit'; in the washer, the work unit is made up of the motors and pumps, the things that do the work."

VISUAL		AUDIO
2.23	CU Electronic control unit.	"In order to do their work, though, each component has to be given directions as to when to start and stop its instructions. These directions are given by what is called the 'control unit'. The control unit is given its instructions, or is programmed, by the manufacturer."
2.24	CU "PROCESSOR" plus "CONTROL-UNIT" and "WORK-UNIT" of machine model.	"The control unit and work unit form a 'team' to process the input."
2.25	"INPUT" — "PROCESSOR" (highlight).	"Once appropriate input is given to the machine, it is relayed to the processor's control unit."
2.26	"CONTROL UNIT" — "WORK UNIT" (highlight).	"After interpreting the input, the control unit sends directions to the work unit, telling it what to do and when to do it."
2.27	"CONTROL UNIT" = "WORK UNIT" (highlight).	"The control unit also monitors the operation of the work unit and turns it off when required."
2.28	"CONTROL UNIT" — "OUTPUT" (highlight).	"When the job has been completed, the control unit then ensures that the output is delivered."
2.29	Overall machine model (no highlights).	"Each of the machines we have considered, the washer, the electric range, and the stereo, operates on this input - process - output principle."

VISUAL		AUDIO
3.1	CU Microcomputer.	"Although appearing to be more complicated, the microcomputer also works on the same general principle."
3.2	MCU Children at microcomputer.	"Microcomputers such as this are small, portable, and relatively inexpensive, and, as a result, are frequently used in the home and by small businesses. These same features make the microcomputer attractive for use in the classroom."
3.3	CU PDP-11.	"Not all computers are as small and as portable as the microcomputer, though. This minicomputer is not only physically bigger and more expensive, it is also more powerful."
3.4	WS Students at terminals, PDP-11 in background.	"The more powerful a computer, the more information it can process and the more people it can serve."
3.5	MCU Child at microcomputer keyboard.	"Like other machines, the computer needs input. On this microcomputer, information is provided using the typewriter-like keyboard."
3.6	CU VDU showing BASIC code.	"The information shown on this display unit is part of the instructions, or program, to display a map of Newfoundland. On the last line, notice the word 'run'; this is the command to direct the computer to carry-out or execute the task it has been given."

	VISUAL	AUDIO
3.7	CU VDU with statement "Please Wait."	"Having provided the input, time is now needed for the processor to interpret and execute the set of instructions."
3.8	CU VDU displaying map of Newfoundland.	"When processing is complete, the output is shown on the video display unit; in this case, the map of Newfoundland."
3.9	Same as 2.29.	"This sequence of events is similar to those involved in the operation of a washer, range, or stereo. Appropriate input is relayed to the processor where it is interpreted and the subsequent work directed by a control unit. When processing is complete, the appropriate output is obtained."
3.10	MCU Children at microcomputer, typing in information.	Music
3.11	MCU Children at microcomputer, displaying map of Newfoundland.	Music
3.12	Credits	Music...(fade)

APPENDIX C

Technical Information

The following materials and equipment were used in the production of Microcomputers: How They Work.

Photography

35 mm film - Kodak ASA (ISO) 400

35 mm camera - Canon AE-1 with 35 mm and 50 mm lens

Filter - FL-D Compensating filter for fluorescent lighting

Location - Cowan Heights Elementary School, St. John's, Newfoundland, and the Learning Resources Division, Faculty of Education, Memorial University, St. John's, Newfoundland

Audio

Narrator: J.P. Baggley

Location: Learning Resources Division, Faculty of Education, Memorial University of Newfoundland, St. John's

Audio Tape: Sony 60 minute low noise audio tape

Music: 'Fanfare' by Elton John

Microcomputer

Microcomputer language: BASIC (Beginners ALL-Purpose Symbolic Instruction Code)

Microcomputer: Radio Shack Model III, 48K RAM

Disc: Memorex Mini Flexible Disc 1 d

APPENDIX D

Multimedia Instructional Package:

Microcomputers: How They Work

- Under Separate Cover